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RDTE PROJECT NO. 1X141807D174
USATECOM PROJECT NO. 4-6-0500-01
USAASTA PROJECT NO. 66-06

# ENGINEERING FLIGHT TEST
# AH-1G HELICOPTER (HUEYCOBRA)

## PHASE D

## PART 3

## VIBRATION CHARACTERISTICS

## FINAL REPORT

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**SEPTEMBER 1970**

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**US ARMY AVIATION SYSTEMS TEST ACTIVITY**
**EDWARDS AIR FORCE BASE, CALIFORNIA 93523**

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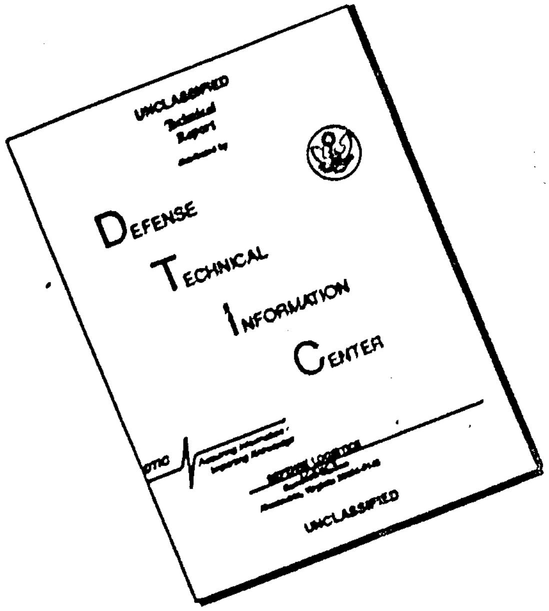


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# ABSTRACT

The Phase D, Part 3 Airworthiness and Qualification Aircraft Vibration Tests of the AH-1G Helicopter were conducted in California at Edwards Air Force Base and auxiliary tests sites during the period 13 June 1968 through 29 July 1969. Six vibration parameters were evaluated to determine model specification compliance and mission suitability information for inclusion in technical manuals and other publications. The vibration levels of the AH-1G met all requirements of the detail model specification; however, a reduction in the vibration levels at airspeeds from maximum level-flight airspeed ($V_H$) to limit airspeed is desirable for improved mission suitability. The detail model specification did not require any specific vibration levels at airspeeds other than $V_H$. Future detail model specifications should contain vibration limits for all flight conditions and aircraft configurations.

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# INTRODUCTION

## BACKGROUND

1. In October, 1965, the Department of the Army directed the US Army Materiel Command (USAMC) to conduct an expedited comparative evaluation of a selected group of three helicopters to fulfill the immediate requirement for an armed helicopter. A flight test program was conducted on the three aircraft by the US Army Aviation Systems Test Activity (USAASTA) at Edwards Air Force Base, California, from 13 November to 1 December 1965. The AH-1G HueyCobra was the aircraft selected from the evaluation to meet the requirement.

2. On 17 August 1966, the USAASTA was directed by the US Army Test and Evaluation Command (USATECOM) to perform Phase B and Phase D testing of the AH-1G helicopter (ref 1, app I). A plan of test for the Phase B engineering test was submitted by USAASTA in April 1967 and approved by the US Army Aviation Systems Command. Phase B tests were conducted at different test sites and geographical locations from 3 April 1967 to 3 May 1968 on several test aircraft. The results of these tests are presented in references 2 through 8. The AH-1G plan of test for the Phase D program (ref 9) was initially submitted in August 1967 and approved by USAAVSCOM on 24 October 1968. The Phase D plan of test was amended on 5 November 1968 to include an additional test, requested by USAAVSCOM (ref 10). Two aircraft were used for Phase D program to reduce the calendar time. One of the test aircraft was a prototype aircraft (S/N 66 15247) and the other was a production model (S/N 67 15695). The results of the Phase D vibration tests are presented in this report (Part 3). The Phase D handling qualities and performance results are presented in other reports (Part 1 and Part 2). No wing store jettison or armament subsystem firing tests were conducted during the Phase D program since adequate testing had been accomplished in these areas during the AH-1G Phase B program.

## TEST OBJECTIVES

3. The test objectives of the AH-1G Phase D test program were as follows:

a. To provide information for technical manuals and other service publications.

b. To determine compliance with applicable military specifications.

c. To determine compliance with contract guarantees.

d. To evaluate operational suitability for the armed helicopter mission requirements.

## DESCRIPTION

4. The AH-1G helicopter, manufactured by Bell Helicopter Company (BHC), was designed specifically to meet the US Army requirement for an armed helicopter. Tandem seating is provided for a two-man crew. The main rotor system is a two-bladed, semirigid, "door-hinge" type with no stabilizer bar. A conventional antitorque rotor is located near the top of the vertical stabilizer. The AH-1G is equipped with a three-axes stability and control augmentation system (SCAS) to improve the aircraft's handling qualities. The helicopter is powered by a Lycoming T53-L-13 turboshaft engine rated at 1400 shaft horsepower (shp) at sea level (SL) under standard day, uninstalled conditions. The engine is derated to 1100 shp because of the maximum torque limit of the main transmission. Distinctive features of the AH-1G are the narrow fuselage (36 inches), the stub midwing with four external store stations and the integral chin turret. The flight control system is of the mechanical, hydraulically boosted, irreversible type with conventional helicopter controls in the aft cockpit (pilot's station). The controls in the forward cockpit (copilot/gunner's station) consist of conventional antitorque pedals and sidearm collective and cyclic controls. An electrically operated force trim system is connected to the cyclic and directional controls to induce artificial feel and to provide positive control centering. The elevator is synchronized with the cyclic stick. The armament configurations are changed by varying the wing stores and chin turret configuration. The pilot operates the wing stores and can fire the chin turret only in the stowed position. The gunner/copilot operates the flexible turret and can also fire the wing stores in an emergency. The wing stores can be jettisoned by either the pilot or gunner in case of emergency. The design gross weight (grwt) of the AH-1G is 6600 pounds and the maximum grwt is 9500 pounds. More detailed aircraft information and operating limits of the AH-1G are presented in appendix II.

## SCOPE OF TEST

5. During the AH-1G Phase D test program, 256 flights were conducted for a total of 368.8 hours of which 227.9 hours were productive. Testing was conducted in California, from 13 June 1968 to 29 July 1969 at Shafter Airport (420-foot elevation), Edwards Air Force Base (2300-foot elevation) and high-altitude test sites near Bishop (4120-, 7010- and 9500-foot elevations). Testing was conducted to determine the aircraft performance, handling qualities and vibration characteristics. This report contains the results of the vibration testing, and Part 1 and Part 2 contain handling qualities and performance test results, respectively. Aircraft serial number (S/N) 67-15695 was used to comply with USAASTA policy of performing vibration tests on a production aircraft when available. No flight time was directly attributed to the vibration tests since all vibration data were obtained during the handling qualities evaluation. The configurations tested during the vibration portion are listed in table 1.

Table 1. Aircraft Armament Configurations.

| Configuration | Armament Subsystems[1] |
|---|---|
| Clean | TAT-102A or XM28 turret, no external wing stores |
| Outboard alternate | TAT-102A or XM28 turret, one XM159 outboard each wing |
| Heavy hog | TAT-102A or XM28 turret, two XM159 each wing |

[1]The test aircraft was equipped with the XM28 turret in the hybrid configuration: one 7.62mm minigun (XM134) and one 40mm grenade launcher (XM129).

6. The test program was conducted within the limitations established by the AH-1G Safety-of-Flight Release issued by USAAVSCOM (refs 11 and 12, app I).

7. The empty weight of the test aircraft in the clean configuration with test instrumentation installed was 5920 pounds with a center of gravity (cg) at fuselage station (FS) 200.69 inches.

8. The AH-1G was evaluated as an armed, tactical helicopter, capable of day or night operation from prepared or unprepared areas. The vibration characteristics of the AH-1G helicopter were evaluated to determine compliance with the requirements of paragraph 3.4.7 of the detail specification (ref 13, app I). Specific conditions for each test are presented in the Results and Discussion section of this report.

## METHODS OF TEST

9. Vibration data were gathered simultaneously during the static stability tests. Data reduction procedures used in these tests are established engineering flight test techniques and are described briefly in appendix III. All flights were conducted and supported by USAASTA personnel. Tests were conducted in nonturbulent atmospheric conditions so the data would not be influenced by uncontrolled disturbances.

10. The flight test data were recorded from test instrumentation in the pilots panel, copilot/gunners panel, and a 50-channel oscillograph. A detailed listing of the test instrumentation is included in appendix IV.

## CHRONOLOGY

11. The chronology of the AH-1G Phase D, Part 3 test program is as follows:

| | | |
|---|---|---|
| Flying portion of the Phase D program commenced | 13 June | 1968 |
| Aircraft S/N 67 15695 received | 8 August | 1968 |
| Flight test commenced on aircraft S/N 67 15695 | 4 September | 1968 |
| Flight test completed on aircraft S/N 67 15695 | 10 October | 1968 |
| Flight test completed on the Phase D program | 29 July | 1969 |
| Draft report completed | May | 1970 |

# RESULTS AND DISCUSSION

## GENERAL

12. This report presents the results of the Phase D vibration analysis of the AH-1G helicopter. The test data obtained during these tests were used for determining compliance with the detail specification (ref 13, app I). The vibration levels of the AH-1G met all requirements of the detail model specification; however, a reduction in the vibration levels at airspeeds from maximum speed for level flight ($V_H$) to limit airspeed ($V_L$) is desirable for improved mission suitability. The detail model specification did not require any specific vibration levels at airspeeds other than $V_H$. Future detail model specifications should contain vibration limits for all flight conditions and aircraft configurations.

## AIRCRAFT CONTROL SYSTEM RIGGING

13. Prior to testing, the aircraft flight and engine controls were checked for correct rigging. Subsequent aircraft flight and engine control rigging changes were coordinated with contractor's technical representatives. Emphasis was placed on optimizing and maintaining the balance and tracking pattern of the main rotor and tail rotor during the test program.

## VIBRATION CHARACTERISTICS

14. The objective of these tests was to define the vibration characteristics of the AH-1G helicopter. Vibration data were recorded in the vertical and lateral direction at three different locations (pilot station, copilot station and mounting plate for chin turret site). The location of each vibration accelerometer is discussed in appendix III. The main rotor vibration harmonics (1/rev, 2/rev, 4/rev, 6/rev and 8/rev) were evaluated. The 10/rev harmonic was not evaluated since previous test results in references 4 and 14, appendix I, indicated that this harmonic was not critical. The test conditions are presented in table 2.

Table 2. Vibration Test Conditions.

| Gross Weight (lb) | Density Altitude (ft) | Rotor Speed (rpm) | Longitudinal Fuselage station (in.) | Configuration | Flight Condition |
|---|---|---|---|---|---|
| 8500 | 4,700 | 324.0 | 201.0 (AFT) | Outboard alternate | Level flight |
| 8470 | 4,980 | 323.5 | 191.4 (FWD) | Clean | |
| 8460 | 4,540 | 324.0 | 201.6 (AFT) | | |
| 7355 | 4,460 | 323.5 | 190.2 (FWD) | | |
| 8525 | 5,360 | 323.5 | 201.0 (AFT) | Heavy hog | |
| 9435 | 3,295 | 323.5 | 200.7 (AFT) | | |
| 8605 | 14,760 | 323.0 | 200.9 (AFT) | | |
| 8600 | 4,610 | 323.5 | 201.0 (AFT) | Outboard alternate | Dive |
| 8240 | 5,440 | 324.0 | 191.2 (FWD) | Clean | |
| 8315 | 4,520 | 324.0 | 201.7 (AFT) | | |
| 7205 | 5,520 | 321.0 | 189.9 (FWD) | | |
| 8640 | 5,380 | 324.5 | 201.0 (AFT) | Heavy hog | |
| 9310 | 3,270 | 324.0 | 200.6 (AFT) | | |
| 8540 | 14,480 | 322.0 | 200.9 (AFT) | | |
| 8170 | 4,950 | 323.0 | 201.7 (AFT) | Clean | Climb |
| 8220 | 6,220 | 324.0 | 201.0 (AFT) | Heavy hog | |
| 8170 | 4,950 | 317.0 | 201.7 (AFT) | Clean | Autorotation |
| 8220 | 6,220 | 320.0 | 201.0 (AFT) | Heavy hog | |

15. Deviation number 3 of the detail model specification (ref 13, app I) presents the vibration requirements for the acceptance of a production aircraft. This deviation is presented in appendix V. The stated requirement established criteria which are applicable at one set of conditions only and do not provide for the entire AH-1G flight envelope for all armament configurations. The vibration limits for each main rotor harmonic, as stated in the deviation, were used as the criteria against which all vibration characteristics were evaluated.

16. The results of the vibration tests, flown to check the guaranteed conditions, are presented in figures 1 through 6, appendix VI. These tests were not conducted at the mid center of gravity (cg) as specified in the detail model specification (ref 13, app I). This condition was the only major variation from the stated deviation mentioned in paragraph 15, and was considered analytically during vibration analysis in determining contract compliance.

17. The vibration levels encountered during the Phase D program agreed generally with the contractor's reported values (ref 14, app I) and the Phase B vibration analysis (ref 4), except in one area. At airspeeds above 120 knots calibrated airspeed (KCAS), vertical 2/rev vibration, at the copilots station during the Phase D program, was higher than previous test results. This increase in the 2/rev vibration level was attributed to the location of the vibration sensor and the aft cg loading. (It is noted in paragraph 20 that the vibration amplitude is larger at an aft cg than at a forward cg for the 2/rev vertical vibration harmonic.) Smaller increases in vibration levels at other frequencies were also encountered, but were attributed to the aft cg loading. The vibration levels recorded during this program, both in the vertical and lateral direction, were well within the requirements of the stated design specification and no crew-member discomfort was encountered at airspeeds below 165 KCAS. At airspeeds in excess of 165 KCAS the vibration levels increased significantly with increasing airspeed. While no difficulty was encountered either in manipulating cockpit controls or reading of the flight instruments, these higher vibration levels increased crew discomfort. The increasing vibration levels at airspeeds approaching $V_L$ provide a cue to the pilot that $V_L$ is being approached. The one vibration harmonic especially noticed by the crew was the vertical 2/rev.

18. The amplitude of the 1/rev was not effected by variations in airspeed. The 2/rev vertical vibration increased with increasing airspeed and, for most conditions tested, was above 0.2g in diving flight. The 2/rev lateral vibration level generally decreased at airspeeds both greater than and less than maximum level-flight

airspeed ($V_H$). The amplitude of the 4/rev vibration frequency was usually in excess of 0.2g in both the vertical and lateral directions at airspeeds in excess of 160 KCAS. The amplitudes of the 6/rev vertical harmonic, at the pilot station and the 6/rev lateral harmonic at the copilot station, increased rapidly at airspeeds in excess of $V_H$. The amplitudes of the other 6/rev vibration harmonic were only slightly affected as airspeed was increased above $V_H$. The magnitude of the 8/rev vibration frequencies were only slightly affected by variations in airspeed.

19. The results of the wing armament comparison tests are presented in figures 7 through 12, appendix VI. The only vibration harmonic which was significantly affected by variations in wing store configuration was the 2/rev. The amplitude of the 2/rev vertical vibration frequency was generally highest in the clean configuration. The 2/rev lateral vibration levels were slightly higher in the heavy hog configuration than the clean configuration and reached a maximum value at $V_H$.

20. A vibration comparison, in the clean configuration at forward and aft cg loadings, is presented in figures 13 through 18, appendix VI. The 2/rev and 4/rev vibration amplitudes, in both the lateral and vertical directions were lower at the forward cg loading. The amplitude of the 2/rev vibration in the vertical direction was affected most by longitudinal cg variations. The magnitudes of the 1/rev, 6/rev and 8/rev harmonics were not affected by longitudinal cg location.

21. The effect of engine power on vibration is presented in figures 19 through 24, appendix VI, where climb and autorotation data were compared for an airspeed range of 40 to 110 KCAS. Engine power had an insignificant effect on vertical vibration at the pilot station at all frequency levels except 6/rev and 8/rev. The magnitude of the vertical 6/rev vibration, at the pilot station, was significantly higher in autorotation than during climb, at airspeeds above 60 KCAS. The amplitude of the 8/rev vibration was generally higher during autorotation than powered flight but was not excessive. The 2/rev lateral vibration harmonic was the only lateral harmonic affected by engine power variations. The 2/rev lateral vibration level increased in magnitude as engine power was increased. This increase in the 2/rev lateral vibration with the variation in engine power was most noticeable in the forward part of the aircraft.

22. The effects of engine power on vibration characteristics in diving flight at airspeeds between $V_H$ and $V_L$ were not investigated during this program. The engine output torque was maintained at or near 50 pounds/inch$^2$ (psi) for airspeeds above $V_H$ during this test

program at density altitudes below 6000 feet. However, vibration characteristics in diving flight are presented in reference 15, appendix I, with the engine torque output at values less than 50 psi.

23. The results of the comparison of vibration characteristics for several gross weights are presented in figures 25 through 36, appendix VI. Gross weight had the most significant effect on the vertical vibration levels at the pilot station. The highest 2/rev and 4/rev vertical vibration levels during the Phase D program, were encountered at the forward cg, light gross weight (7200 lb), clean configuration. The maximum magnitudes of the 2/rev and 4/rev were 0.385 and 0.545 g's, respectively, at an airspeed of 189 KCAS. The vertical vibration level decreased as gross weight was increased. This decrease was more noticeable at the higher airspeeds. The magnitude of the lateral vibrations was generally unaffected by the gross weight variations, for all main rotor harmonics.

24. The effect of altitude on vibration characteristics is presented in figures 37 through 42, appendix VI. The vertical and lateral vibration characteristics and levels were similar at density altitudes of 5000 and 15,000 feet. Comparing the two altitudes shows a general increase in the 4/rev vibration level at the same calibrated airspeed. It was also noted that increasing airspeed while at or near $V_L$, at 15,000 feet, did not result in the same increase in the vibration levels as had been encountered at 5000 feet.

# CONCLUSION

25. The vibration characteristics of the AH-1G helicopter were suitable for mission use for all flight conditions and configurations less than $V_H$. For airspeeds between $V_H$ and $V_L$, the vibration levels increased and caused increased crew discomfort (para 17).

26. The 2/rev and 4/rev vertical vibrations in the clean configuration were excessively high at the light gross weight (7200 lb), airspeeds in excess of $V_H$ (para 23).

27. The vibration characteristics meet the requirements established in the AH-1G detail model specification (ref 13, app I) (paras 16 and 17).

28. The approved deviation of reference 13, appendix I does not establish adequate standards for the evaluation of all configurations and normal flight conditions of the AH-1G helicopter (para 15).

# RECOMMENDATIONS

29. The vibration levels at airspeeds between $V_H$ and $V_L$ be reduced to improve mission suitability (para 17).

30. Future detail model specifications contain vibration limits for all flight conditions and aircraft configurations (para 15).

# APPENDIX I. REFERENCES


1. Letter, USATECOM, AMSTE-GB, subject: Test Directive Engineering and Logistical Evaluation Test of the AH-1G Helicopter (Huey Cobra).

2. Final Report, US Army Aviation Test Activity (USAAVNTA), Project No. 66-06, *Engineering Flight Test of the AH-1G Helicopter, Huey-Cobra, Phase B, Part 1*, January 1968.

3. Final Report, USAAVNTA, Project No. 66-06, *Engineering Flight Test of the AH-1G Helicopter to Determine the Area of Adequate Directional Control Power at 8100 Pounds Gross Weight*, February 1968.

4. Final Report, USAASTA, Project No. 66-06, *Engineering Flight Tests of the AH-1G Helicopter, HueyCobra, Phase B, Part 2*, May 1969.

5. Final Report, USAAVNTA, Project No. 67-26 (66-06), *Engineering Flight Test of the AH-1G (HueyCobra) Helicopter Equipped with the XM-28 Chin Turret with Twin XM-134 Miniguns, Phase B, Part 3*, March 1968.

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7. Final Report, USAAVNTA, Project No. 68-03 (66-06), *Engineering Flight Test of the AH-1G Helicopter Equipped with the XM-28 Chin Turret with One 7.62mm Automatic Gun (M-134) and One 40mm Grenade Launcher (MX-129) Hybrid, Phase B, Part 5*, April 1968.

8. Final Report, USAASTA, Project No. 66-06, *Engineering Flight Test of the AH-1G Helicopter (HueyCobra) Phase B, Part 6*, November 1969.

9. Preliminary Test Plan, USAAVNTA, Project No. 66-06C, *Engineering Flight Test of the AH-1G (HueyCobra) Phase D*, August 1968.

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11. Message, USAAVSCOM, AMSAV-EF 7-1385, unclas, subject: AH-1G Safety of Flight Release, 26 July 1967.

12. Message, USAAVSCOM, AMSAV-R-EF 11-1315, unclas, subject: Flight Release for the AH-1G Without Skid Gear Fairings, 6 November 1968.

13. Specification, Bell Helicopter Company, Report No. 209-947-050, *Detail Specification for Model AH-1G Helicopter FY-68 Procurement*, 25 September 1967.

14. Specification, Bell Helicopter Company, Report No. 209-099-044, *Results of Flight Vibration Survey of the Model AH-1G Helicopter*, 17 July 1967.

15. Final Report, USAAVNTA, Project No. 65-30, *Engineering Flight Evaluation of the Bell Model 209 Armed Helicopter*, May 1966.

# APPENDIX II. BASIC AIRCRAFT INFORMATION AND OPERATING LIMITS

AIRFRAME

Rotor System

The 540 "door hinge" main rotor assembly is a two-bladed, semi-rigid, underslung feathering axis type rotor. The assembly consists basically of two all-metal blades, blade grips, yoke extensions, yoke trunnion, and rotating controls. Control horns for cyclic and collective control input are mounted on the trailing edge of the blade grip. Trunnion bearings permit rotor flapping. The blade grip to yoke extension bearings permit cyclic and collective pitch action.

Tail Rotor

The tail rotor is a two-bladed, delta-hinge type employing preconing and underslinging. The blade and yoke assembly is mounted to the tail rotor shaft by means of delta-hinge trunnion. Blade pitch angle is varied by movement of the tail rotor control pedals. Power to drive the tail rotor is supplied by a takeoff on the lower end of the main transmission.

Transmission System

The transmission is mounted forward of the engine and coupled to the engine by a short drive shaft. The transmission is basically a reduction gear box which transmits engine power at reduced rpm to the main and tail rotors by means of a two-stage planetary gear train. The transmission incorporates a free-wheeling unit at the input drive. This provides a disconnect from the engine in case of a power failure to allow the aircraft to make an autorotional landing.

Synchronized Elevator

The synchronized elevator, which has an inverted airfoil section, is located near the aft end of the tail boom and is connected by control tubes and mechanical linkage to the fore and aft cyclic control system. Fore and aft movements of the cyclic control stick produce a change in the synchronized elevator attitude.

Control Systems

A dual hydraulic control system is provided for the cyclic and collective controls. The directional controls are powered by a single servo cylinder which is operated by system No. 1. The hydraulic system consists of two hydraulic pumps, two reservoirs, relief valves, shut-off valves, pressure warning lights, lines, fittings, and manual, dual tandem, servo actuators incorporating irreversible valves. Tandem power cylinders incorporating closed center four-way manual servo valves and irreversible valves are provided in the lateral, fore and aft cyclic and collective control system. A single power cylinder incorporating a closed center four-way manual servo valve is provided in the directional control system. The cylinders contain a straight-through mechanical linkage.

Force Trim

A magnetic brake and force gradient device is incorporated in the cyclic control and directional pedal controls. These devices are installed in the flight control system between the cyclic stick and the hydraulic power cylinders and between the directional pedals and the hydraulic power cylinder. The force trim control can be turned off by depressing the left button on the top of the cyclic stick. The gradient is accomplished by springs and magnetic brake release assemblies which enable the pilot to trim the controls as desired.

Cyclic Control Stick

The pilot and gunner cyclic stick grip each have a force trim switch and a SCAS release switch. The pilot's cyclic stick has a built-in operating friction. The cyclic control movements are transmitted directily to the swash plate. The fore and aft cyclic control linkage is routed from the cyclic stick through the SCAS actuator, to the dual boost hydraulic actuator and then to the right horn of the fixed swash plate ring. The lateral cyclic is similarly routed to the left horn.

Collective Pitch Control

The collective pitch control is located to the left of the pilot and is used to control the vertical mode of flight. Operating friction can be induced into the control lever by hand tightening the friction adjuster. The pilot and gunner collective pitch controls have a rotating grip-type throttle.

## Tail Rotor Pitch Control Pedals

Tail rotor pitch control pedals alter the pitch of the tail rotor blades and thereby provide the means for directional control. The force trim system is connected to the directional controls and is operated by the force trim switch on the cyclic control grip.

## Stability and Control Augmentation System (SCAS)

The SCAS is a three-axis, limited-authority, rate-referenced stability augmentation system. It includes an electrical pilot input which augments the pilot's mechanical control input. This system permits separate consideration of airframe displacements caused by external disturbances from displacements caused by pilot input. The SCAS is integrated into the fore, aft, lateral and directional flight controls to improve the stability and handling qualities of the helicopter. The system consists of electro-hydraulic servo actuators, control motion transducers, a sensor/amplifier unit and a control panel. The servo actuator movements are not felt by the pilot. The actuators are limited to a 25-percent authority and will center and lock in case of electrical and/or hydraulic failure.

# ENGINE

## Engine Description

The T53-L-13 engine, rated at 1400 shp, is a successor to the T53-L-11 engine. The additional power has been achieved with no change in the basic T53-L-11 engine envelope mounting and connection points and with a 6-percent increase in basic engine weight.

The performance gain is accomplished thermodynamically by the mechanical integration of a modified axial compressor, a two-stage compressor turbine and a two-stage power turbine into the T53-L-11 engine configuration.

Replacement of the first two compressor stators and changing of the first two stages of compressor rotor blades and disks results in an approximate 20-percent increase in mass air flow through the engine. This is accomplished without the use of inlet guide vanes.

An inlet flow fence, located on the outer wall of the inlet housing in the area of the previously used inlet guide vanes, provides the desired inlet conditions for the transonic compressor during acceleration at low speeds. At compressor speeds up to 70 percent, the fence is in the extended position. Above 70 percent, the flow fence is retracted into the outer wall of the inlet housing. Similar to a piston ring, the circumference of the flow fence is changed by the action of a piston actuator powered by compressor discharge pressure.

The specification for this engine allows the use of JP-4 or JP-5 type fuel for satisfactory operation throughout the engine's operating envelope. During this program, JP-4 fuel was used.

Engine Power Control System

The fuel control for the T53-L-13 engine is a hydro-mechanical type of fuel control. It consists of the following main units:

a. Dual-element fuel pump.

b. Gas producer speed governor.

c. Power turbine speed topping governor.

d. Acceleration and deceleration control.

e. Fuel shut-off valve.

f. Transient air bleed control.

An air bleed control is incorporated within the fuel control to provide for opening and closing the compressor interstage air bleed in response to the following signals present in the power control:

a. Gas producer speed.

b. Compressor inlet air temperature.

c. Fuel flow.

The fuel control is designed to be operated either automatically or in an emergency mode. In the emergency position, fuel flow is terminated to the main metering valve and is routed to the manual (emergency) metering and dump valve assembly. While in the emergency mode, fuel flow to the engine is controlled by the position of the manual metering valve which is directly connected to the power control (twist grip). During the emergency operation, there is no automatic control of fuel flow during acceleration and deceleration; thus, EGT and engine acceleration must be pilot-monitored.

## BASIC AIRCRAFT INFORMATION

### Airframe Data

| | |
|---|---|
| Overall length (rotor turning) | 637.2 inches |
| Overall width (rotor trailing) | 124.0 inches |
| Center line of main rotor to center line of tail rotor | 320.7 inches |
| Center line of main rotor to elevator hinge line | 198.6 inches |
| Elevator area (total) | 15.2 square feet |
| Elevator area (both panels) | 10.9 square feet |
| Elevator airfoil section | Inverted Clark Y |
| Vertical stabilizer area | 18.5 square feet |
| Vertical stabilizer airfoil section | Special camber |
| Vertical stabilizer aerodynamic center | FS 499.0 |
| Wing area: | |
| Total | 27.8 square feet |
| Outboard of BL 18.0 (both sides) | 18.5 square feet |
| Wing span | 10.33 feet |
| Wing airfoil section: | |
| Root | NACA 0030 |
| Tip | NACA 0024 |
| Wing angle of incidence | 14 degrees |

### Main Rotor Data

| | |
|---|---|
| Number of blades | 2 |
| Diameter | 44 feet |
| Disc area | 1520.5 square feet |
| Blade chord | 27 inches |
| Rotor solidity | 0.0651 |
| Blade area (both blades) | 99 square feet |
| Blade airfoil | 9.33 percent symm special section |
| Linear blade twist | -0.455 deg/ft |
| Hub precone angle | 2.75 degrees |

### Antitorque Rotor Data

| | |
|---|---|
| Number of blades | 2 |
| Diameter | 8.5 feet |
| Disc area | 56.74 square feet |
| Blade chord | 8.41 inches |
| Rotor solidity | 0.105 |
| Blade airfoil | NACA 0010 modified |
| Blade twist | Zero degrees |

Transmission Drive System Ratios

| | |
|---|---|
| Engine to main rotor | 20.383:1.0 |
| Engine to antitorque rotor | 3.990:1.0 |
| Engine to antitorque drive system | 1.535:1.0 |

Test Aircraft Control Displacements

| | |
|---|---|
| Longitudinal cyclic control: | |
| Full forward to full aft with SCAS nulled | 10.03 inches |
| Lateral cyclic control: | |
| Full left to full right with SCAS nulled | 9.90 inches |
| Directional (pedal) control: | |
| Full left to full right with SCAS nulled | 5.97 inches |
| Collective control: | |
| Full up to full down with SCAS nulled | 8.96 inches |

## OPERATING LIMITATIONS

### Limit Airspeed ($V_L$)

Any configuration with XM159 rocket pods: 180 KCAS below a 3000-foot density altitude; decrease 8 KCAS per 1000 feet above 3000 feet

For this test, the AH-1G with skid gear fairings removed: same as standard configurations (Normal limit for operational use: 160 KCAS)

All other configurations: 190 KCAS below a 4000-foot density altitude; decrease 8 KCAS per 1000 feet above 4000 feet

### Gross Weight/Center of Gravity Envelope

Forward center of gravity limit: Below 7000 pounds, FS 190.0; linear increase to FS 192.1 at 9500 pounds

Aft center of gravity limit: Below 8270 pounds, FS 201.0 linear decrease to FS 200 at 9500 pounds

### Sideslip Limits

Five degrees at $V_L$ with linear increase to 20 degrees at 60 KCAS

Rotor and Engine Speed Limits (Steady State)

| | |
|---|---|
| Power on: | |
| Engine rpm | 6400 to 6600 |
| Rotor rpm | 314 to 324 |
| Power off: | |
| Rotor rpm | 294 to 339 |
| Rotor rpm transient lower limit | 250 |
| Power on during dives and maneuvers: | |
| Rotor rpm | 314 to 324 |

Temperature and Pressure Limits

| | |
|---|---|
| Engine oil temperature | 93°C |
| Transmission oil temperature | 110°C |
| Engine oil pressure | 25 to 100 psi |
| Transmission oil pressure | 30 to 70 psi |
| Fuel pressure | 5 to 20 psi |

T53-L-13 Engine Limits

| | |
|---|---|
| Normal rated EGT (maximum continuous) | 625°C |
| Military rated EGT (30-minute limit) | 645°C |
| Starting and acceleration EGT (5-second limit) | 675°C |
| Maximum EGT for starting and acceleration | 760°C |
| Torque pressure limit | 50 psi |

# APPENDIX III. TEST TECHNIQUES AND DATA REDUCTION PROCEDURES

## INTRODUCTION

### Instrumentation

1. The instrumentation was calibrated prior to commencing the test program. A detailed tabulation of the instrumentation is given in appendix IV. All quantitative data obtained during this flight test program were obtained from special sensitive instrumentation. Data were obtained from three sources: oscillograph, pilot's panel (hand recorded) and engineer's panel (hand recorded). Vibration data were recorded on the oscillograph. The vibration sensors used and their location in the aircraft are shown in photographs 1, 2 and 3.

| | Photo 1 | Photo 2 | Photo 3 |
|---|---|---|---|
| Fuselage station | 145.8 | 81.3 | 51.8 |
| Buttline | 10.0 RT | 10.0 RT | 0.0 |
| Waterline | 70.5 | 57.0 | 50.5 |

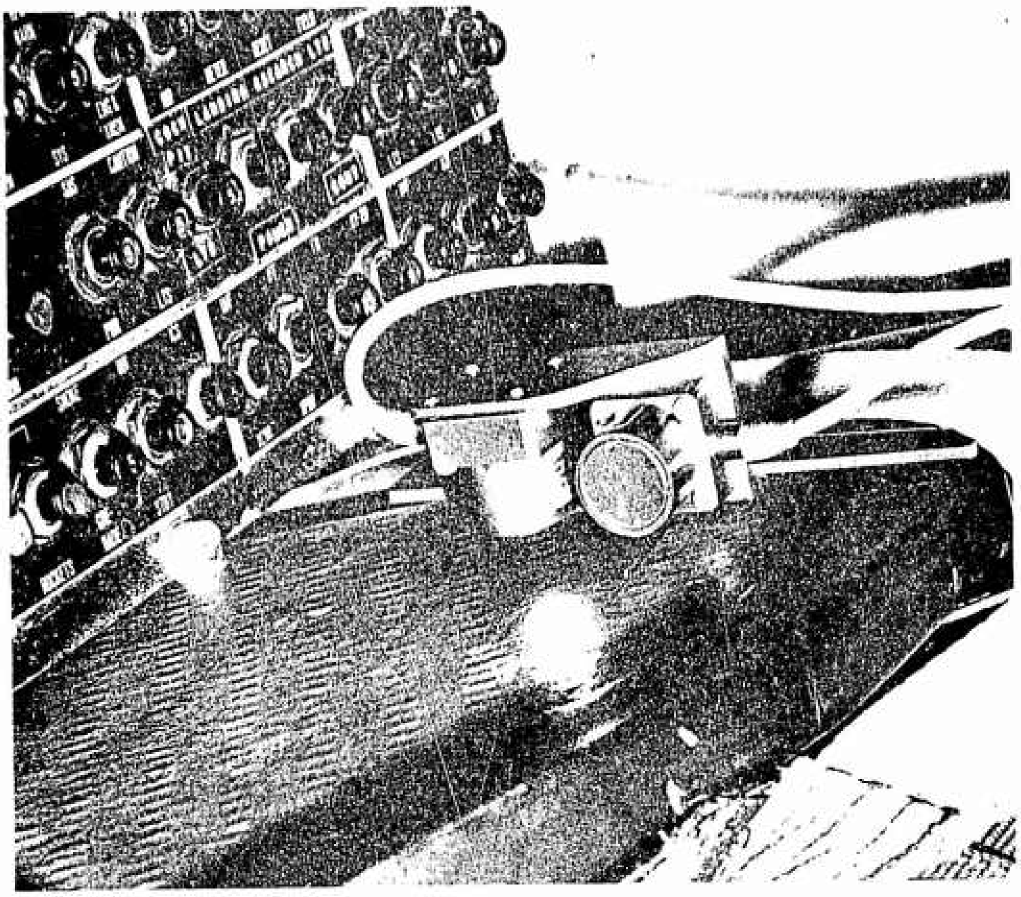


Photo 1. Vertical and Lateral Vibration Sensors Located at the Pilot's Station.

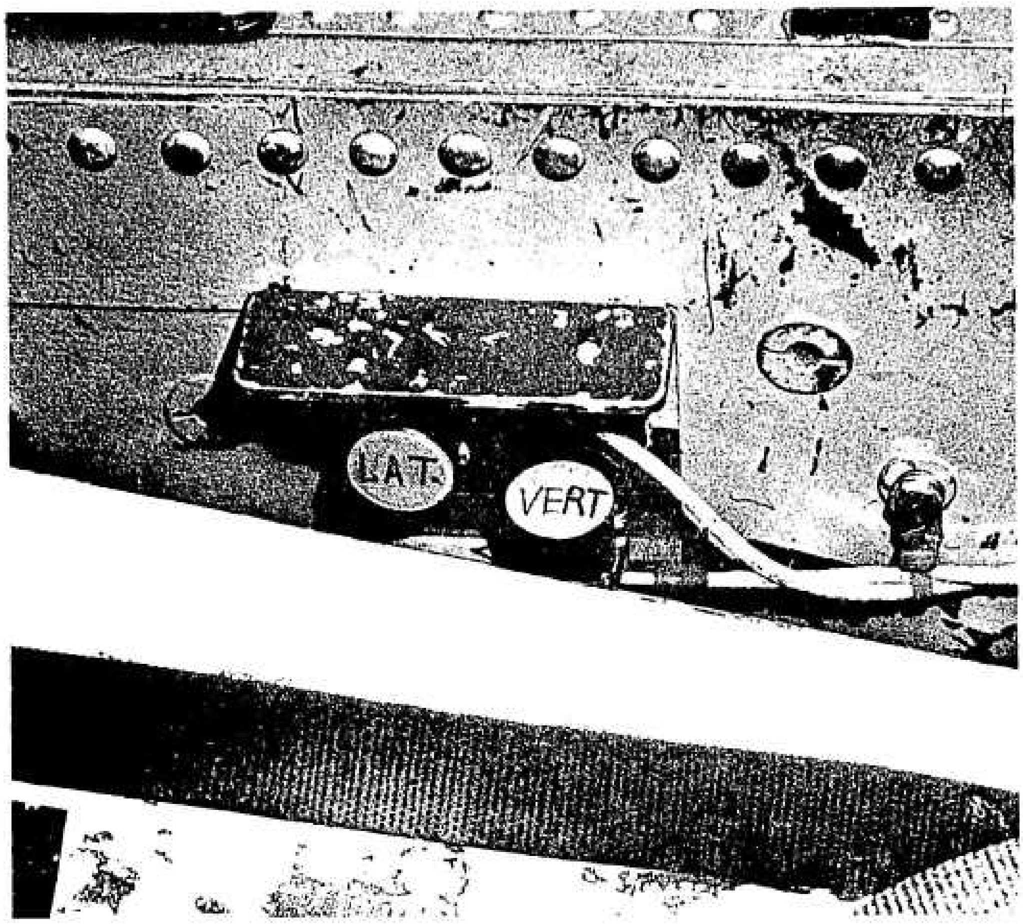



Photo 2. Vertical and Lateral Vibration Sensors Located at the Copilot/Gunner's Station.

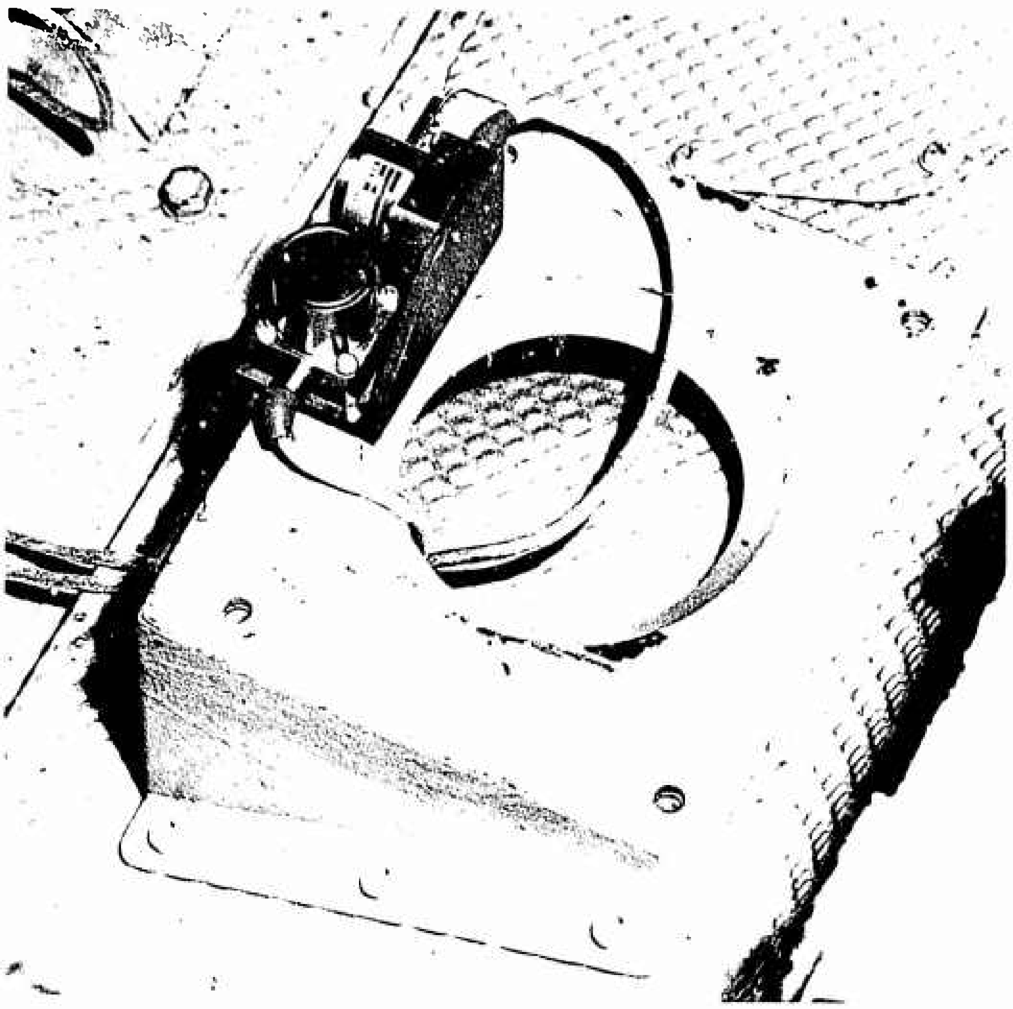


Photo 3. Vertical and Lateral Vibration Sensors Located at the Site Mount for the Chin Turret.

## Weight and Balance

2. The weight and balance of the test helicopter was carefully maintained. Variations in empty weight and cg due to change in helicopter component and/or instrumentation were defined by periodic weighings.

3. The empty weight of the test aircraft in the clean configuration without instrumentation installed was 5805 pounds, and the longitudinal cg was 201.4 inches. This aircraft is representative of the production model aircraft. This weighing was performed with the following conditions prevailing:

a. Engine and transmission full of oil.

b. Trapped fuel not drained.

c. Empty ammunition boxes with covers and ammunition chutes installed for chin turret.

d. Four wing store pylon stations installed.

e. Optional air conditioning system not installed.

f. Weight and center of gravity adjusted for removal of jack pads.

4. The fuel load of the aircraft was defined by measuring the fuel specific gravity and temperature after each fueling, and by using an external sight gauge on the calibrated fuel cell to determine fuel volume. Fuel used in flight was recorded by a calibrated fuel-used system, and the results were cross checked with the sight gauge reading following each flight. Helicopter loading and cg were controlled by using ballast located at specific aircraft stations.

## Vibration

5. Vibration tests were performed at various combinations of gross weight, center of gravity, wing store configurations and density altitude, to determine if variation of these parameters caused a change in the vibration characteristics. Each individual test flight was accomplished at a constant main rotor thrust coefficient ($C_T$). A constant $C_T$ was maintained (for flights conducted at altitude) by increasing altitude as fuel was consumed. The thrust coefficient varied slightly during climb, autorotation and dive testing. The engine power output was maintained at or near 50 psi

during flight for all vibration tests at density altitudes less than 6000 feet. All vibration data were gathered simultaneously during the static stability tests. Equation 1 was used to determine the nondimensional main rotor thrust coefficient.

$$\text{Thrust coefficient} = C_T = \frac{GRWT}{\rho A(\Omega R)^2} \qquad (1)$$

6. To determine the components of the aircraft vibration levels at the fundamental frequency (1/rev) of the main rotor and at the 2/rev, 4/rev, 6/rev and 8/rev harmonics of the main rotor frequency, the vibration data were Fourier analyzed. This analysis was accomplished using digital techniques. The data were sampled at equal time intervals to produce time series of discrete samples. These time series represent the continuous vibration data for all frequencies less than one-half the sampling rate.

7. To Fourier analyze the time series of discrete samples, the discrete Fourier transform (DFT) was used. The calculation of the DFT's of the time series were accomplished using a highly efficient computation algorithm called the fast Fourier transform (FFT). This algorithm takes advantage of the fact that the calculation of the Fourier coefficients of the DFT can be carried out iteratively, and results in considerable savings in computer time.

# APPENDIX IV. TEST INSTRUMENTATION

All instrumentation was installed in the test helicopter (USA S/N 67 15695) prior to the start of the test program. This instrumentation provided data from three sources: pilot panel (photo A), copilot/engineer panel (photo B) and a 50-channel oscillograph (photo C). All instrumentation was calibrated. The flight test instrumentation was installed and maintained by the Instrumentation Branch, Logistics Division, USAASTA. The following parameters were measured:

PILOT PANEL

Airspeed (boom system)
Altitude (boom system)
Rate of climb
Rotor speed
Gas producer speed
Torque pressure (standard system)
Longitudinal control position
Lateral control position
Pedal control position
Collective control position
CG normal acceleration
Angle of sideslip

ENGINEER PANEL

Airspeed (boom system)
Altitude (boom system)
Outside air temperature
Rotor speed
Torque pressure (standard system)
Fuel used total
Oscillograph correlation center

OSCILLOGRAPH

Longitudinal control position
Lateral control position
Directional control position
Collective control position
Pitch attitude
Roll attitude

Yaw attitude
Pitch rate
Roll rate
Yaw rate
Angle of attack
Angle of sideslip
CG normal acceleration
Longitudinal SCAS position
Lateral SCAS position
Direction SCAS position
Rotor blip
Vertical and lateral vibration sensors (pilot seat)
Vertical and lateral vibration sensors (engineer seat)
Pilot event
Engineer event
Vertical and lateral vibration sensors
(gun site mounts for chin turret)

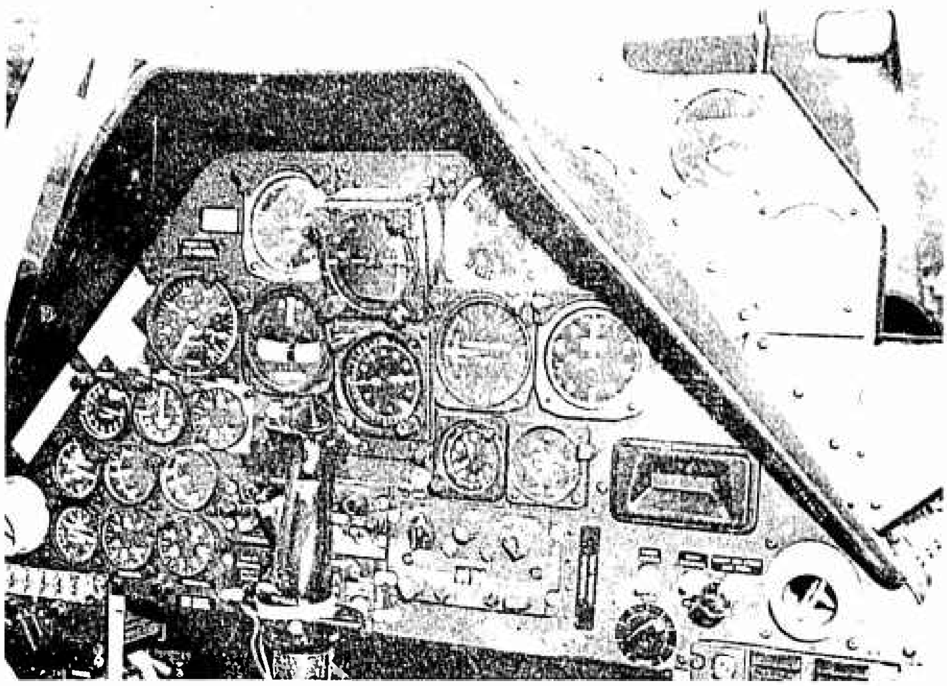


Photo A. Pilot Instrument Panel.

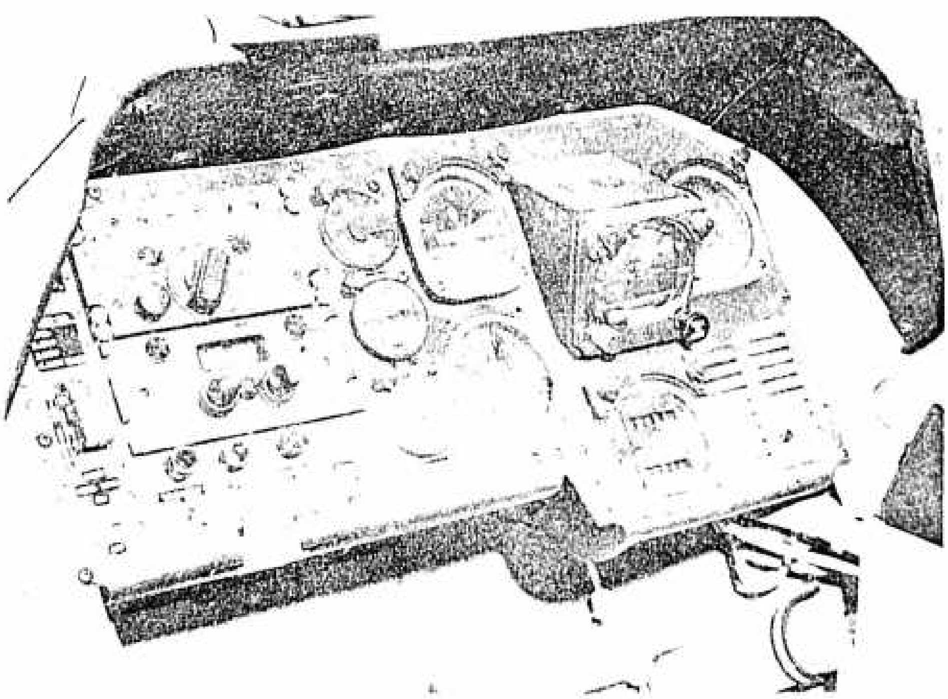


Photo B. Copilot/Gunner Instrument Panel.

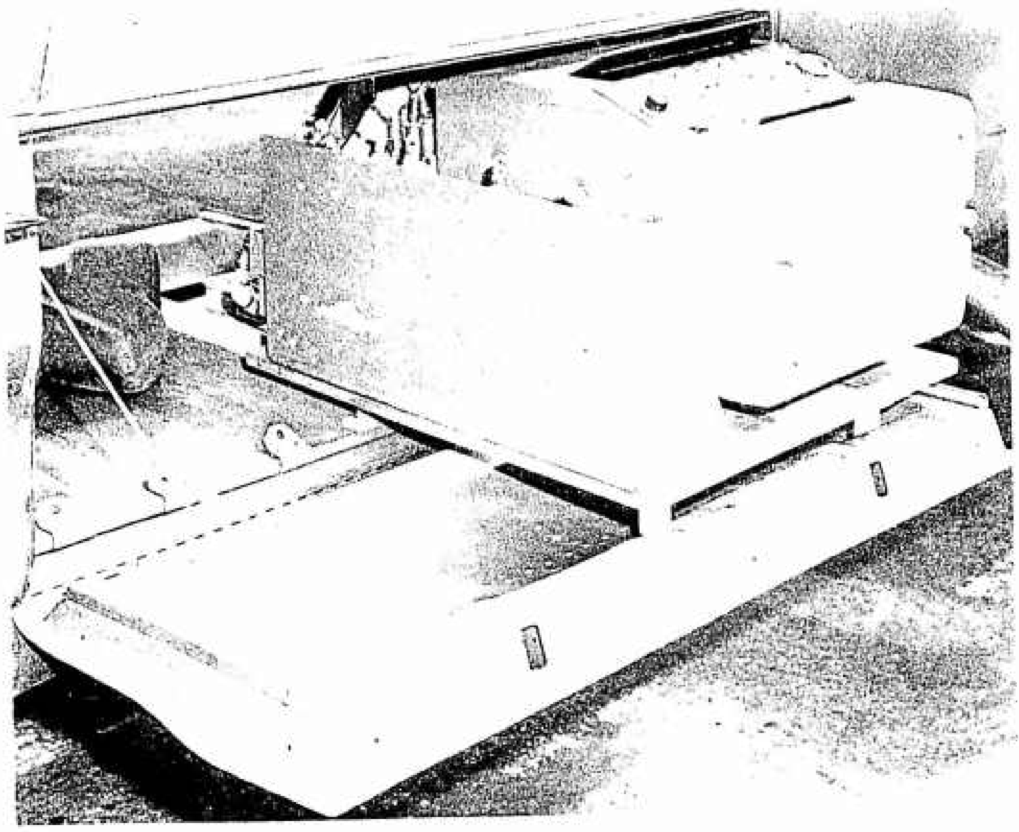


Photo C. Oscillograph Installation.

# APPENDIX V. APPROVED CONTRACT DEVIATION FROM MIL-H-8501A

Rotor induced fuselage and cyclic stick vibration shall be measured in accordance with, and shall not exceed, the levels of MIL-H-8501.

| Contractor deviation | Paragraph in reference 11, app I | Subject |
|---|---|---|
| 3 | 3.4.7 | Rotor induced vibration |

REQUIREMENT: Paragraph 3.7.1(b) of MIL-H-8501A specifies that: Vibration accelerations at the pilot, crew, passenger and litter stations at all steady speeds between 30 knots rearward and $V_{cruise}$ shall not exceed 0.15 g for frequencies up to 32 cps and a double amplitude of 0.003 inch for frequencies greater than 32 cps. From $V_{cruise}$ to $V_{limit}$ the maximum vibratory acceleration shall not exceed 0.2 g up to 36 cps, and a double amplitude of 0.003 inch for frequencies greater than 36 cps. At all frequencies above 50 cps a constant velocity vibration of 0.039 shall not be exceeded.

DEVIATION: For the acceptance of production aircraft, the vibration level shall be objectionable if the measurements of representative aircraft taken at the pilot's station, gunner's station and gun sight(s) mounting structure indicate values in excess of:

| Single Amplitude G | Rotor Harmonic |
|---|---|
| 0.10 | 1/R |
| 0.20 | 2/R |
| 0.20 | 4/R |
| 0.25 | 6/R |
| 0.30 | 8/R |
| 0.40 | 10/R |

The flight conditions shall be:

1. Density altitude of 2500 feet.

2. Stabilized level flight.

3. 1100 at main transmission input.

4. Nineteen round rocket pods on outboard store station (unfaired).

5. Gross weight/$\sigma$ ratio of 7500 pounds minimum.

6. Center of gravity between fuselage stations 193 and 194 (in.).

7. Main rotor rpm of 324.

Reason: To define vibration characteristics required of the AH-1G helicopter.

# APPENDIX VI. TEST DATA

FIGURE NO. 1

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

CONTRACT GUARANTEE COMPLIANCE CHECK

| GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIGURATION | FLT. COND. |
|---|---|---|---|---|---|
| 8500 | 4700 | 324.0 | 201.0 (AFT) | OUTB'D ALTER. | LEVEL FLT. |
| 8600 | 4610 | 323.5 | 201.0 (AFT) | OUTB'D ALTER. | DIVE |

NOTE: LEVEL FLIGHT DENOTED BY OPEN SYMBOL
DIVE DENOTED BY SHADED SYMBOL

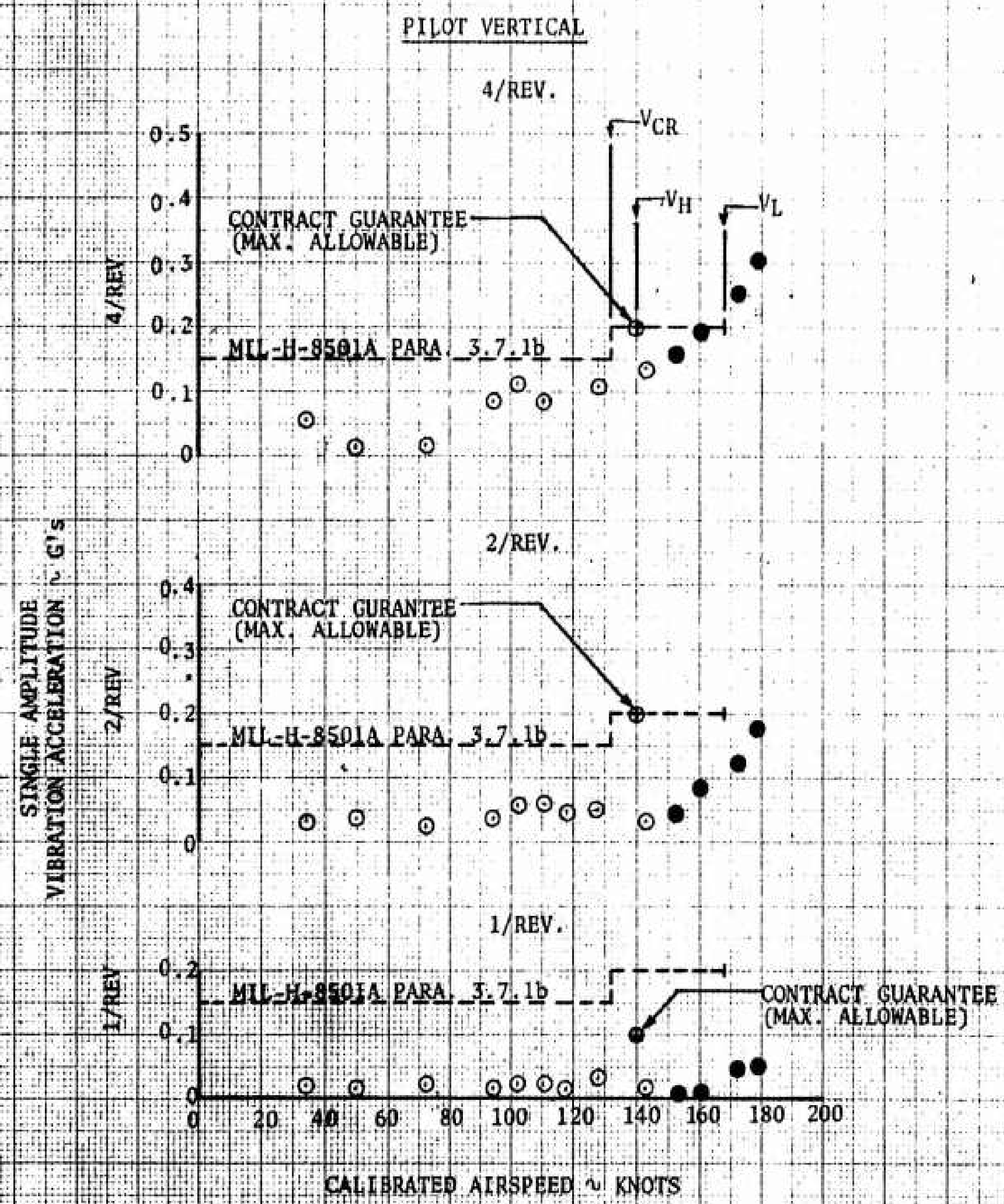


FIGURE NO. 1 CONTINUED

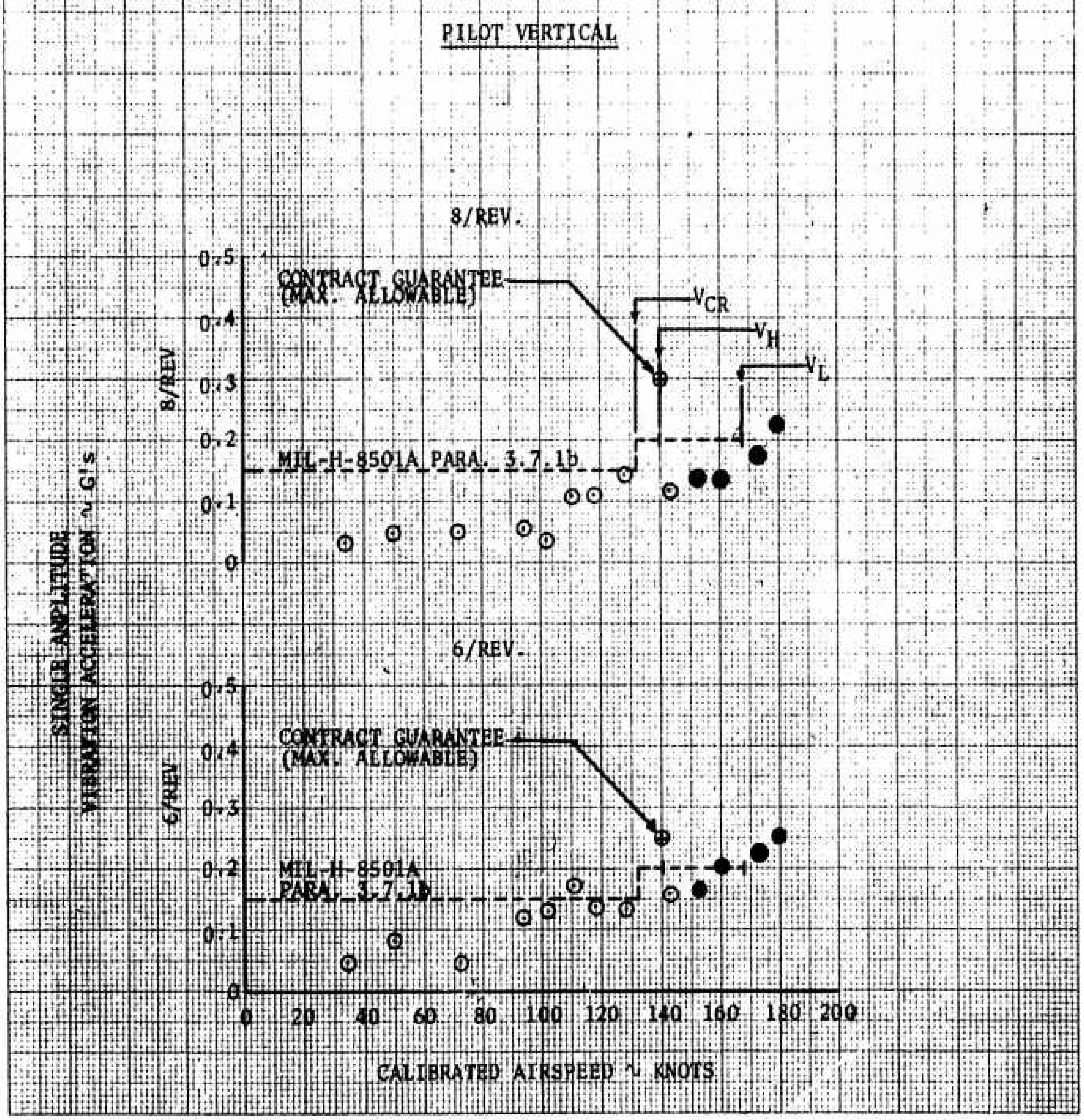


FIGURE NO. 2

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

CONTRACT GUARANTEE COMPLIANCE CHECK

| GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIGURATION | FLT. COND. |
|---|---|---|---|---|---|
| 8500 | 4700 | 324.0 | 201.0 (AFT) | OUTB'D ALTER. | LEVEL FLT. |
| 8360 | 4610 | 323.5 | 201.0 (AFT) | OUTB'D ALTER. | DIVE |

NOTE: LEVEL FLIGHT DENOTED BY OPEN SYMBOL
DIVE DENOTED BY SHADED SYMBOL

COPILOT VERTICAL

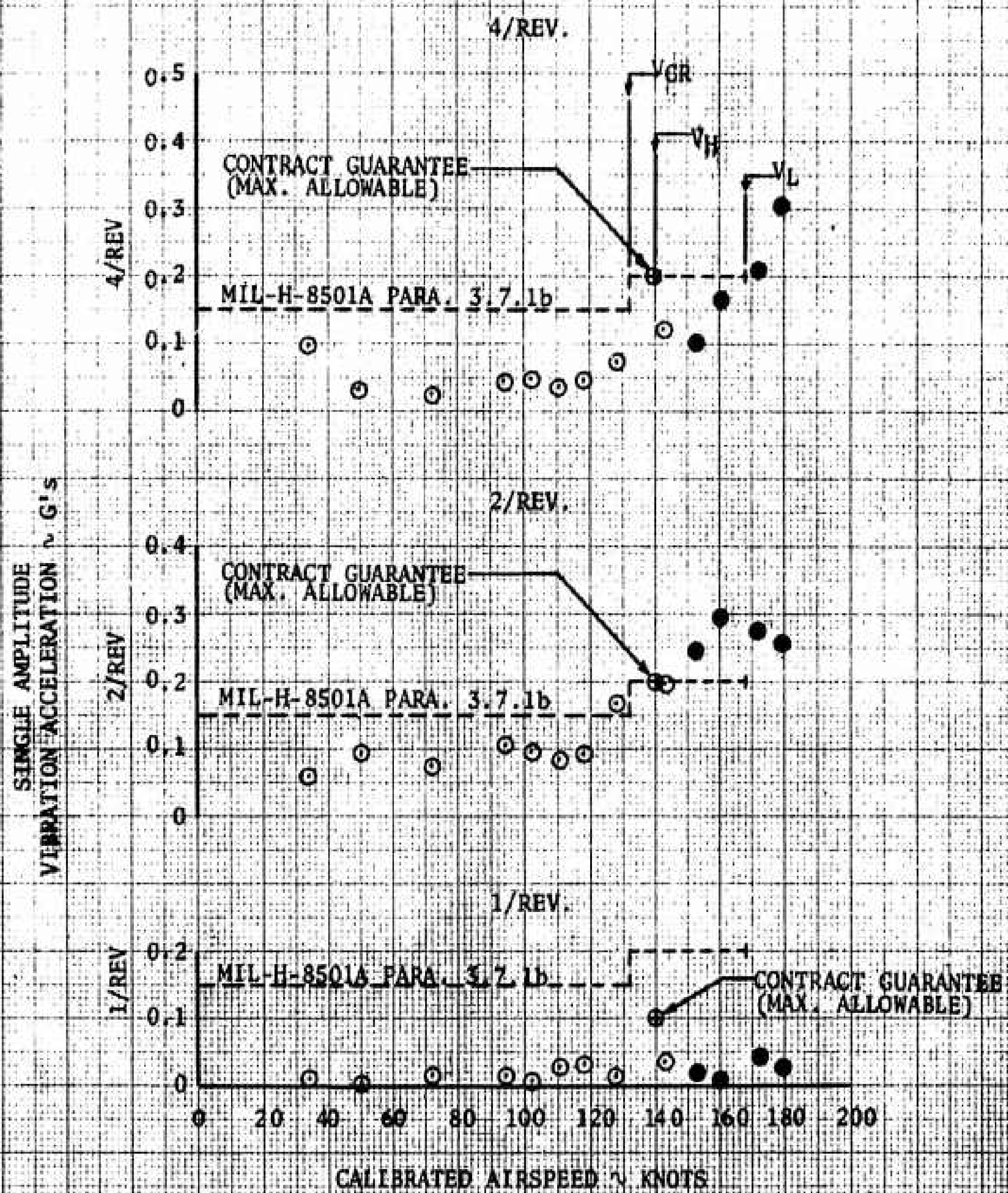


FIGURE NO. 2 CONTINUED

COPILOT VERTICAL

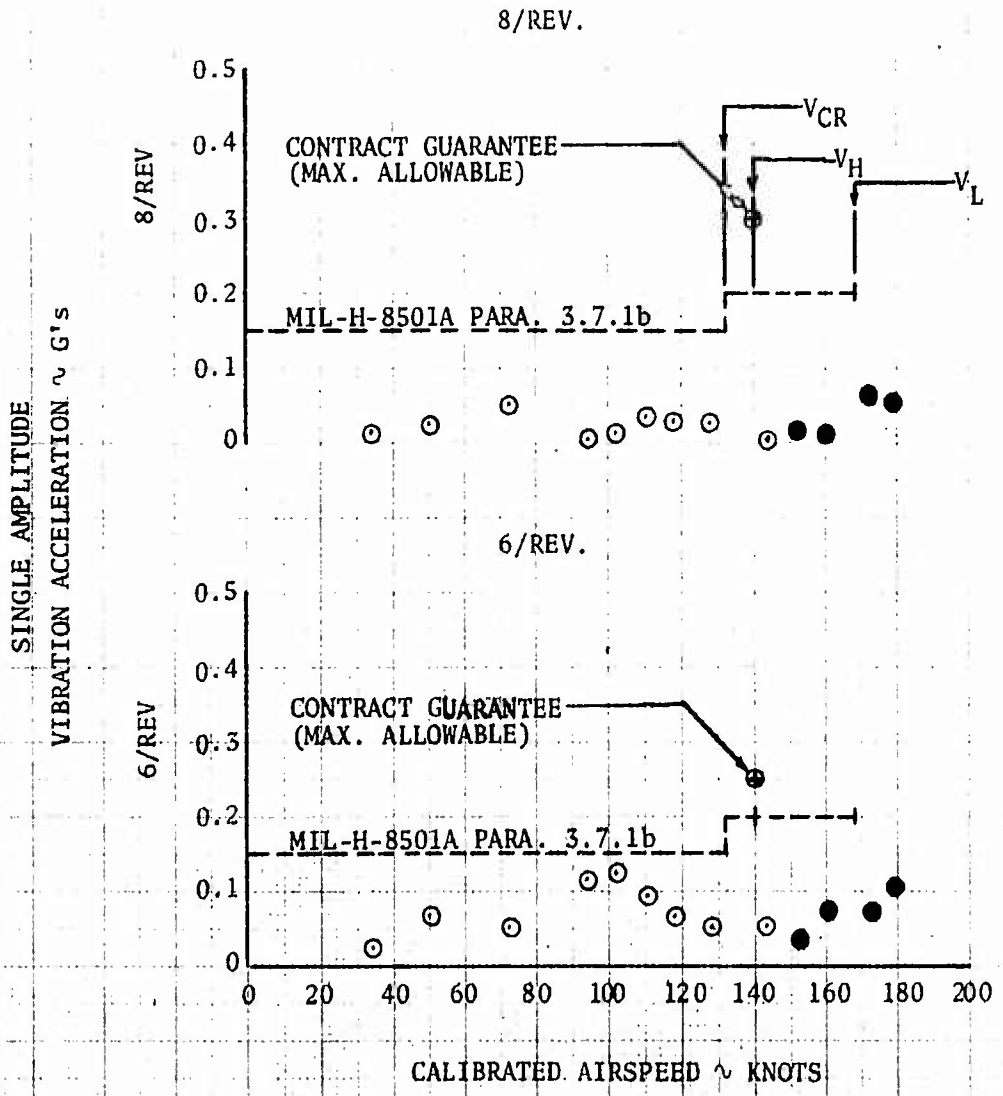


FIGURE NO. 3
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695
CONTRACT GUARANTEE COMPLIANCE CHECK

| GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIGURATION | FLT. COND. |
|---|---|---|---|---|---|
| 8500 | 4700 | 324.0 | 201.0 (AFT) | OUTB'D ALTER. | LEVEL FLT. |
| 8360 | 4610 | 323.5 | 201.0 (AFT) | OUTB'D ALTER. | DIVE |

NOTE : LEVEL FLIGHT DENOTED BY OPEN SYMBOL
DIVE DENOTED BY SHADED SYMBOL

SITE MOUNTING VERTICAL

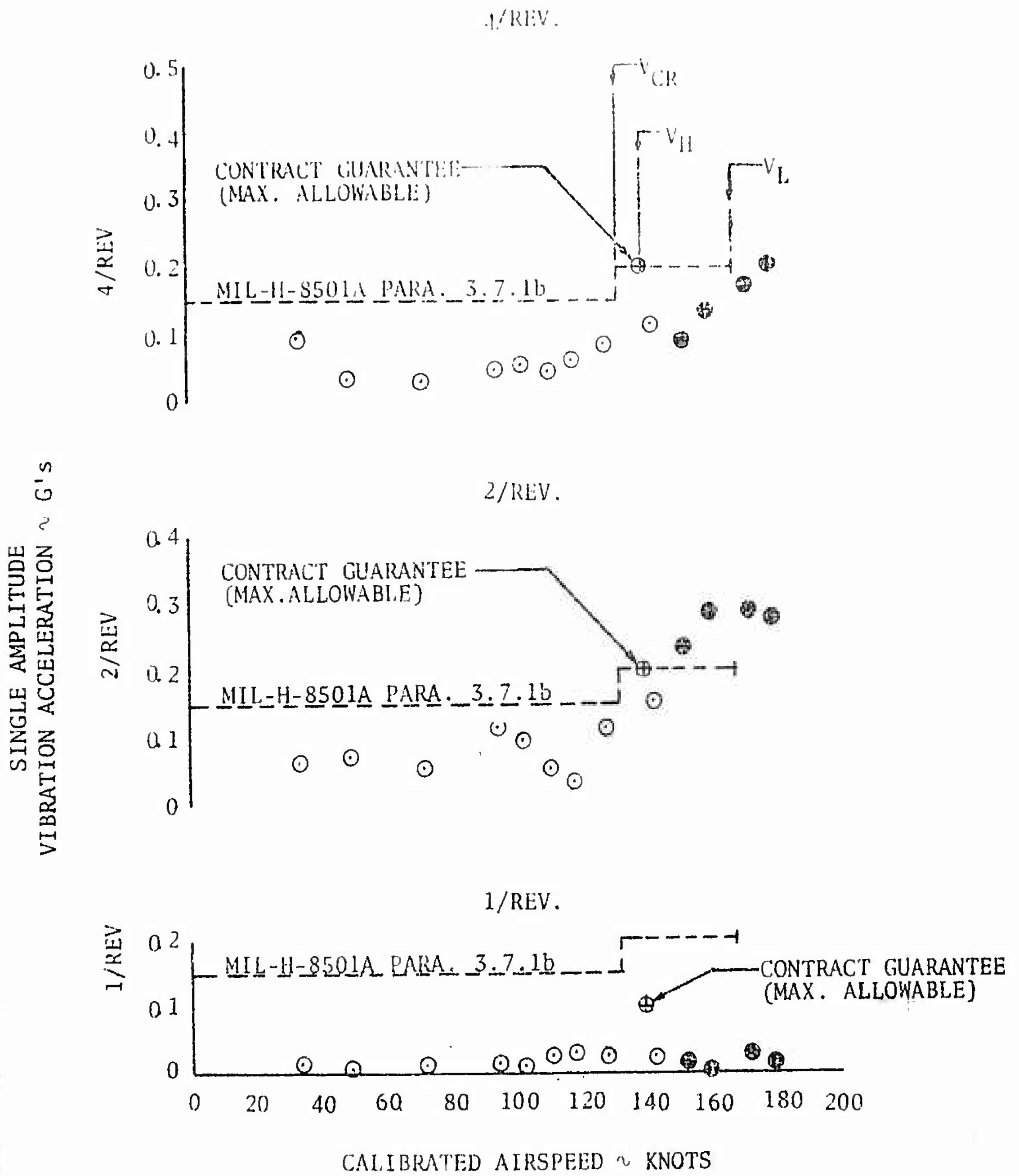


FIGURE NO. 3 CONTINUED

SITE MOUNTING VERTICAL

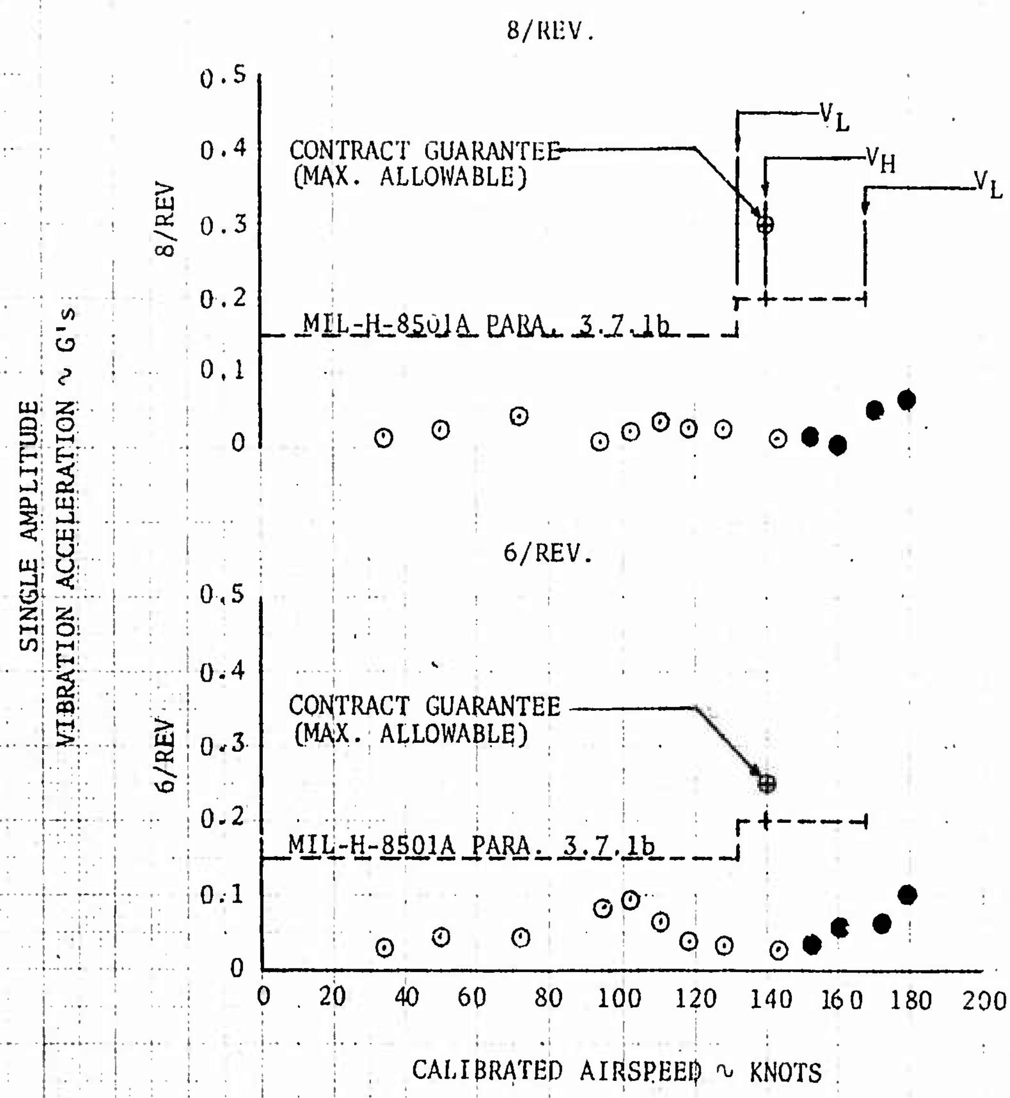


FIGURE NO. 4
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695
CONTRACT GUARANTEE COMPLIANCE CHECK

| GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIGURATION | FLT. COND. |
|---|---|---|---|---|---|
| 8500 | 4700 | 324.0 | 201.0 (AFT) | OUTB'D ALTER. | LEVEL FLT. |
| 8360 | 4610 | 323.5 | 201.0 (AFT) | OUTB'D ALTER. | DIVE |

NOTE: LEVEL FLIGHT DENOTED BY OPEN SYMBOL
DIVE DENOTED BY SHADED SYMBOL

PILOT LATERAL

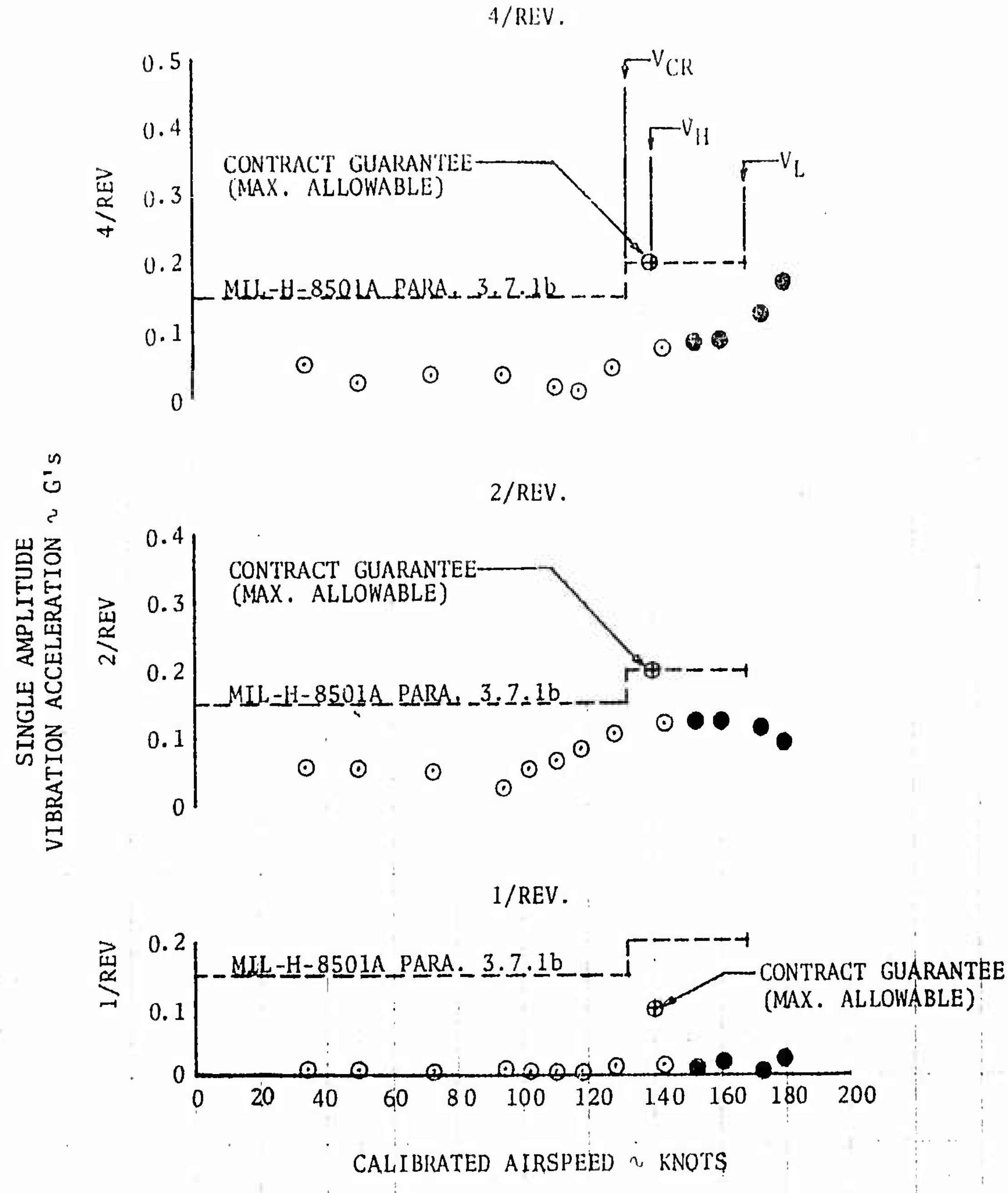


FIGURE NO. 4 CONTINUED

PILOT LATERAL

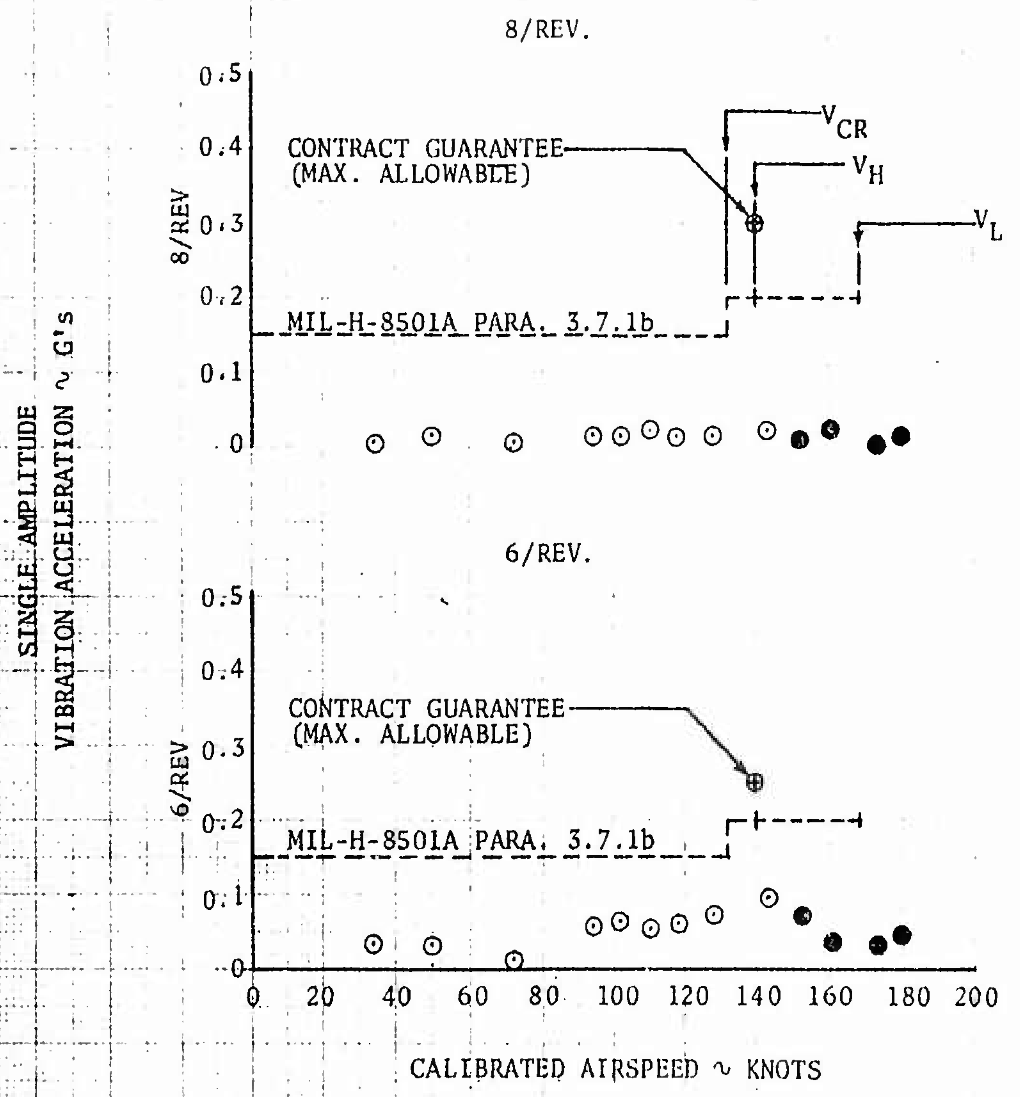


FIGURE NO. 5

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

CONTRACT GUARANTEE COMPLIANCE CHECK

| GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIGURATION | FLT. COND. |
|---|---|---|---|---|---|
| 8500 | 4700 | 324.0 | 201.0 (AFT) | OUTB'D ALTER. | LEVEL FLT. |
| 8360 | 4610 | 323.5 | 201.0 (AFT) | OUTB'D ALTER. | DIVE |

NOTE: LEVEL FLIGHT DENOTED BY OPEN SYMBOL
DIVE DENOTED BY SHADED SYMBOL

COPILOT LATERAL

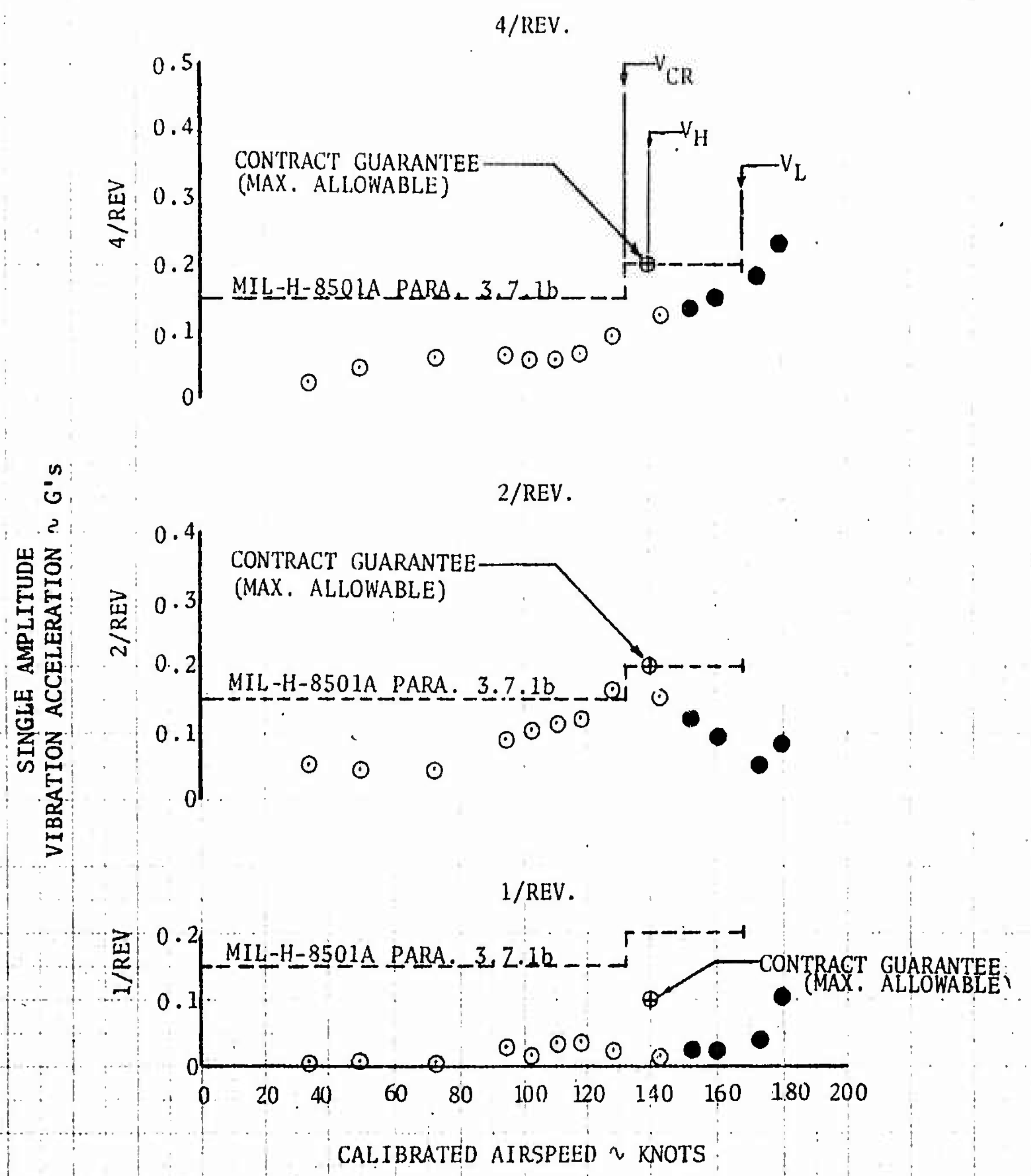


FIGURE NO. 5 CONTINUED

COPILOT LATERAL

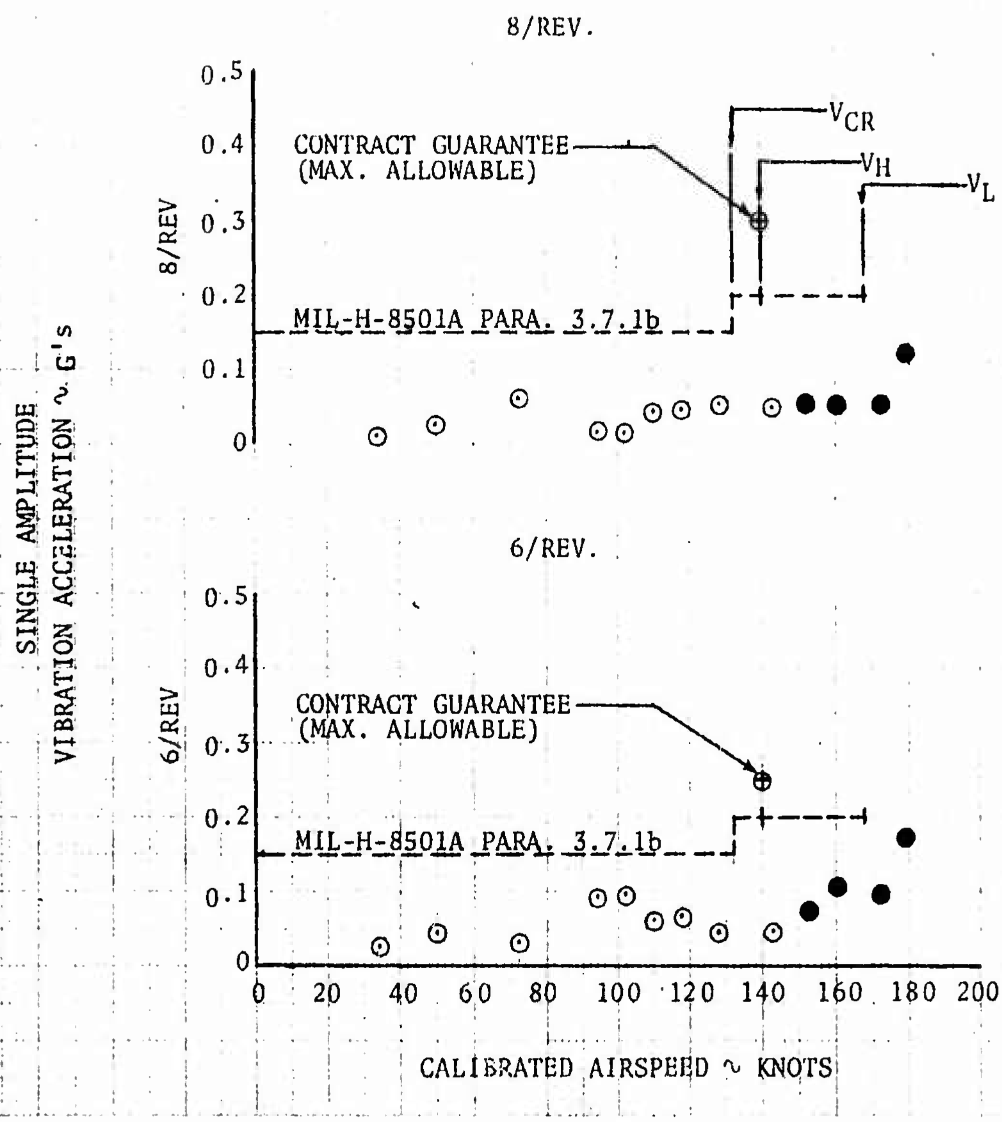


FIGURE NO. 6

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

CONTRACT GUARANTEE COMPLIANCE CHECK

| GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIGURATION | FLT. COND. |
|---|---|---|---|---|---|
| 8500 | 4700 | 324.0 | 201.0 (AFT) | OUTB'D ALTER. | LEVEL FLT. |
| 8360 | 4610 | 323.5 | 201.0 (AFT) | OUTB'D ALTER. | DIVE |

NOTE: LEVEL FLIGHT DENOTED BY OPEN SYMBOL

DIVE DENOTED BY SHADED SYMBOL

SITE MOUNTING LATERAL

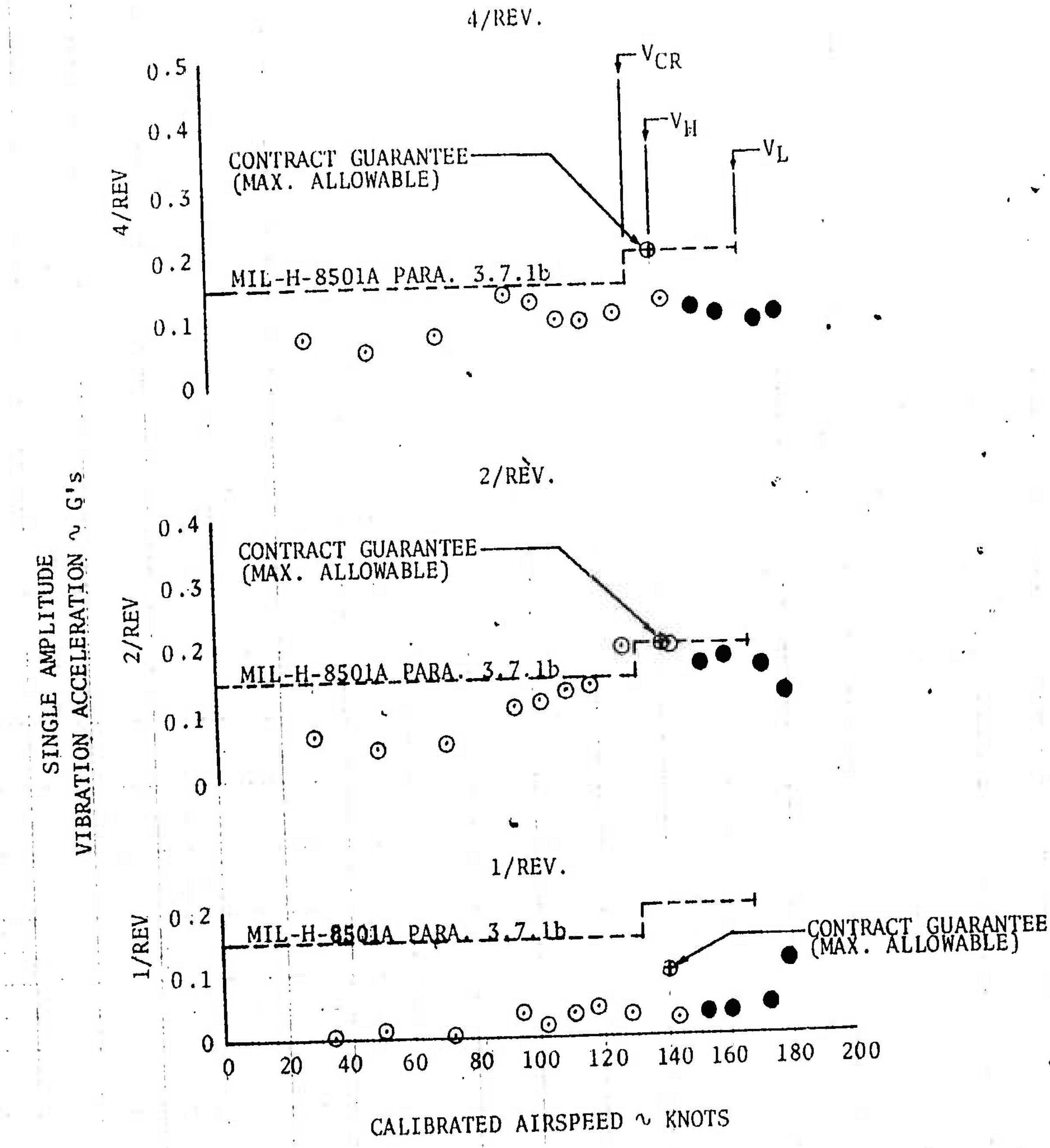


FIGURE NO. 6 CONTINUED

SITE MOUNTING LATERAL

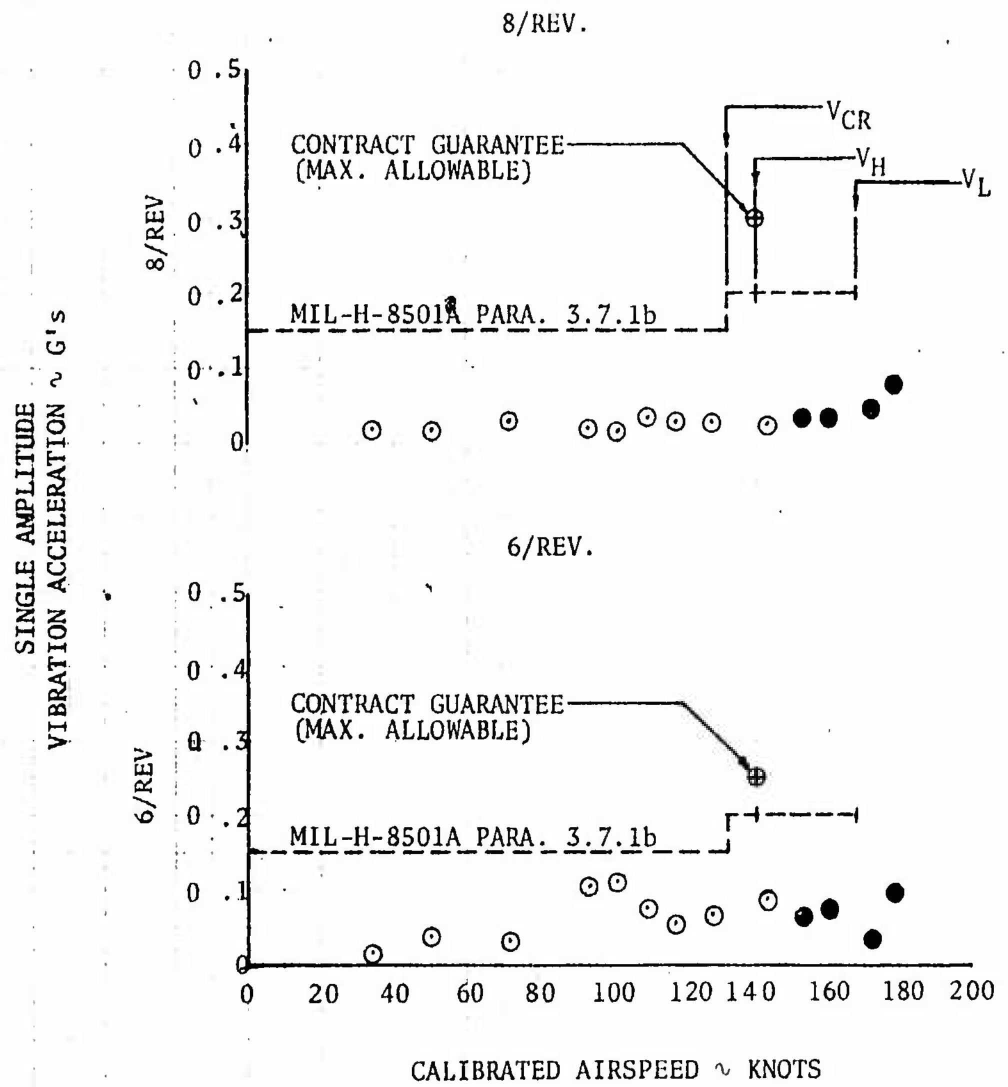


FIGURE NO. 7
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.[illegible] (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

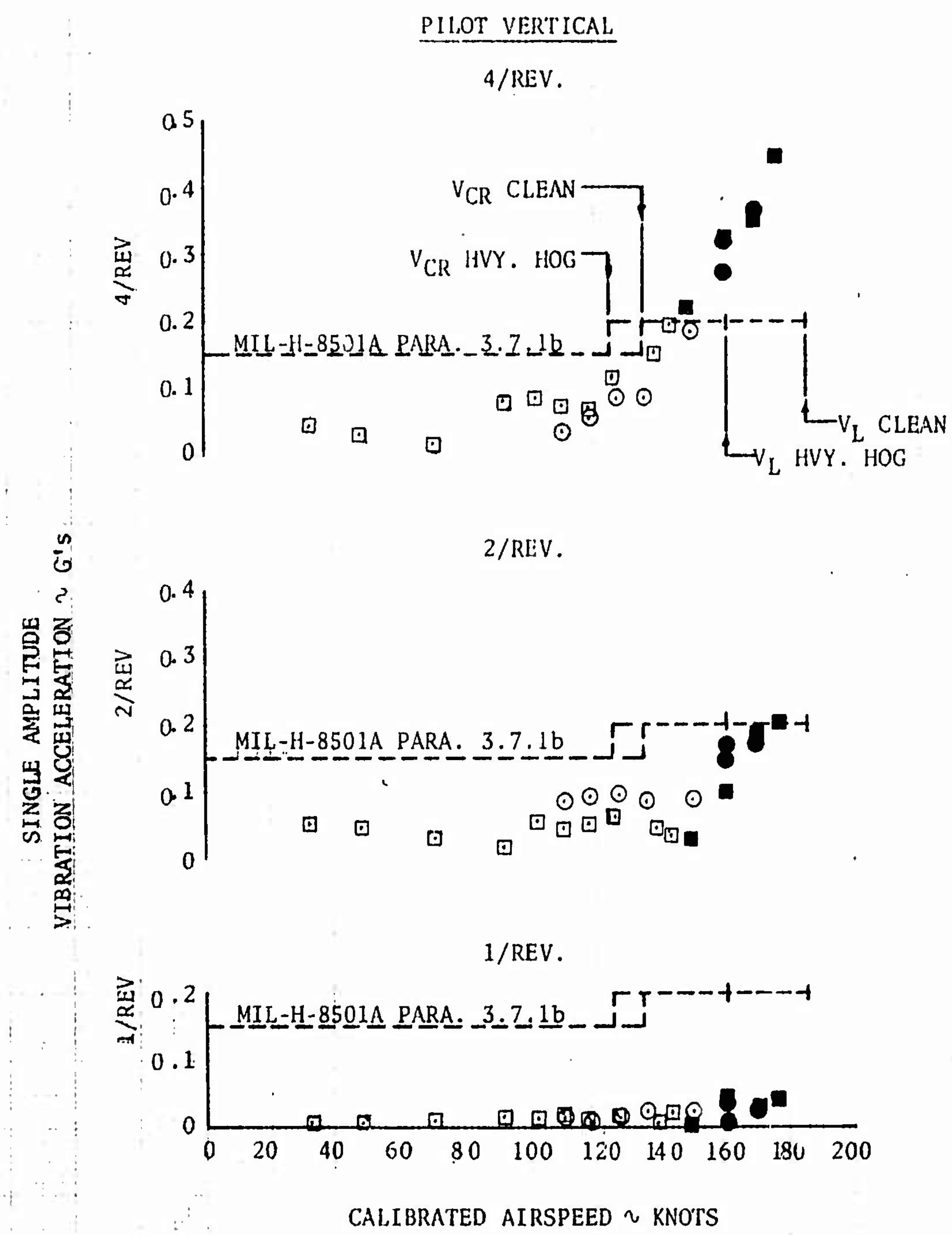


FIGURE NO. 7 CONTINUED

PILOT VERTICAL

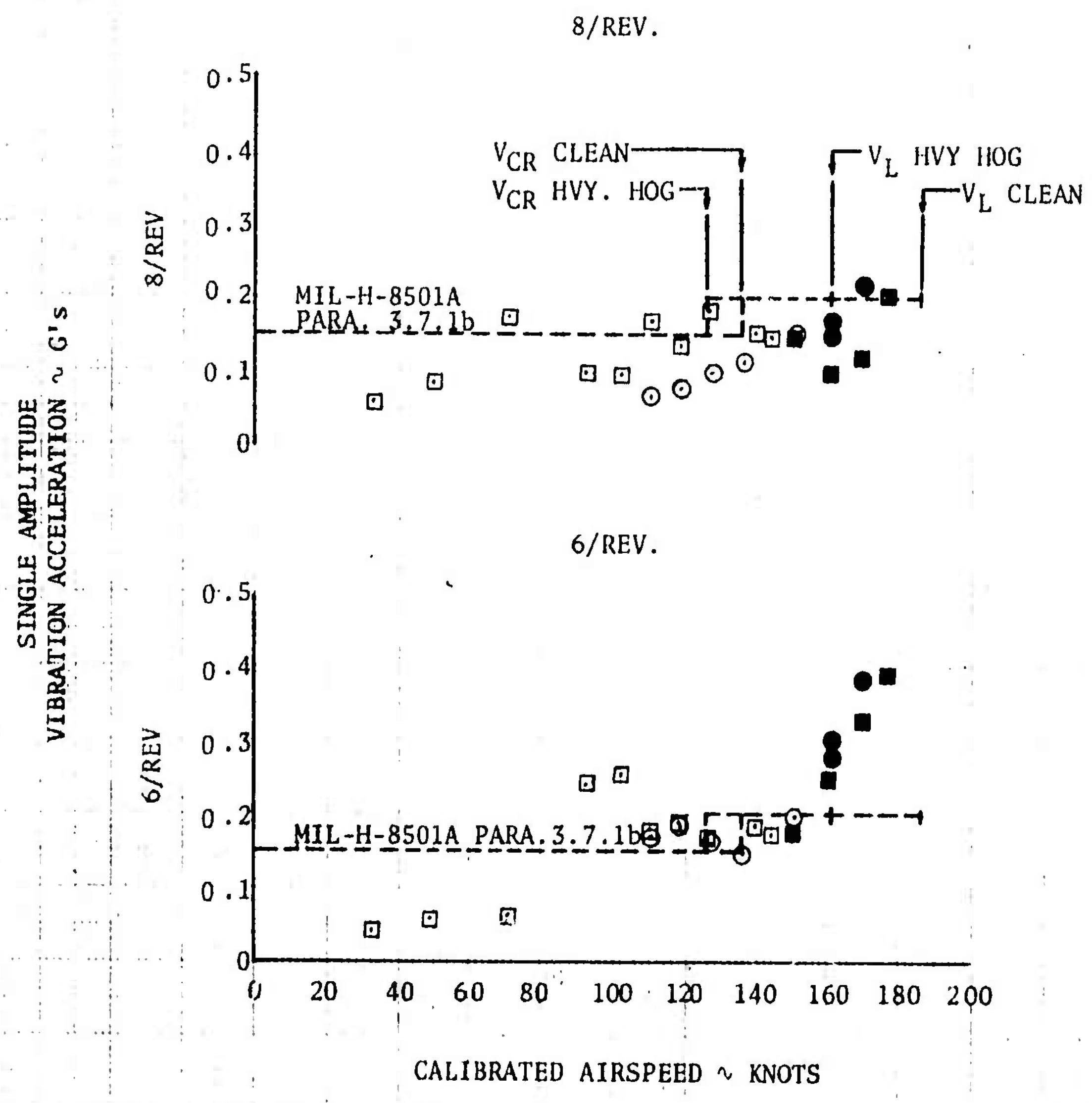


FIGURE NO. 8

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

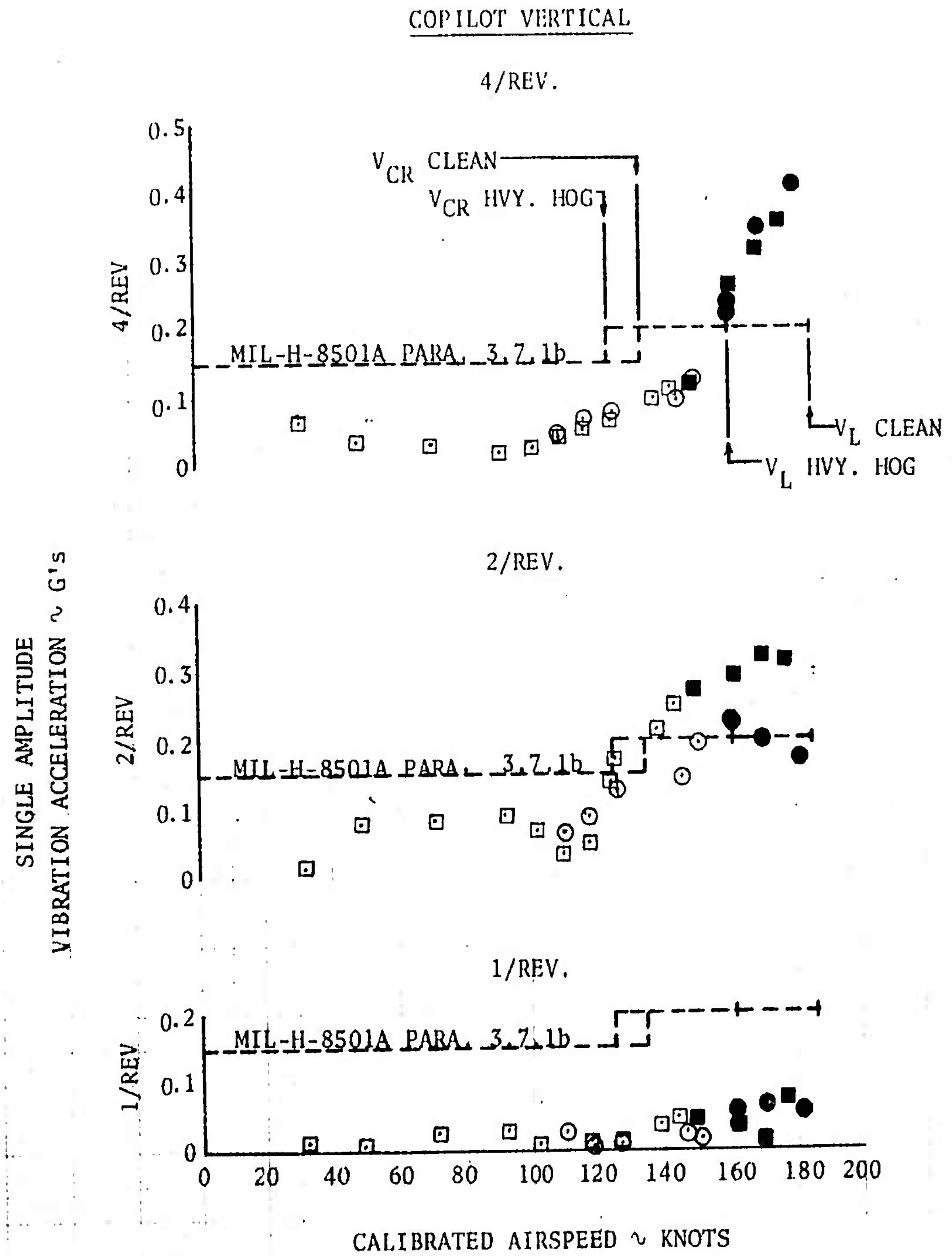


FIGURE NO. 8 CONTINUED

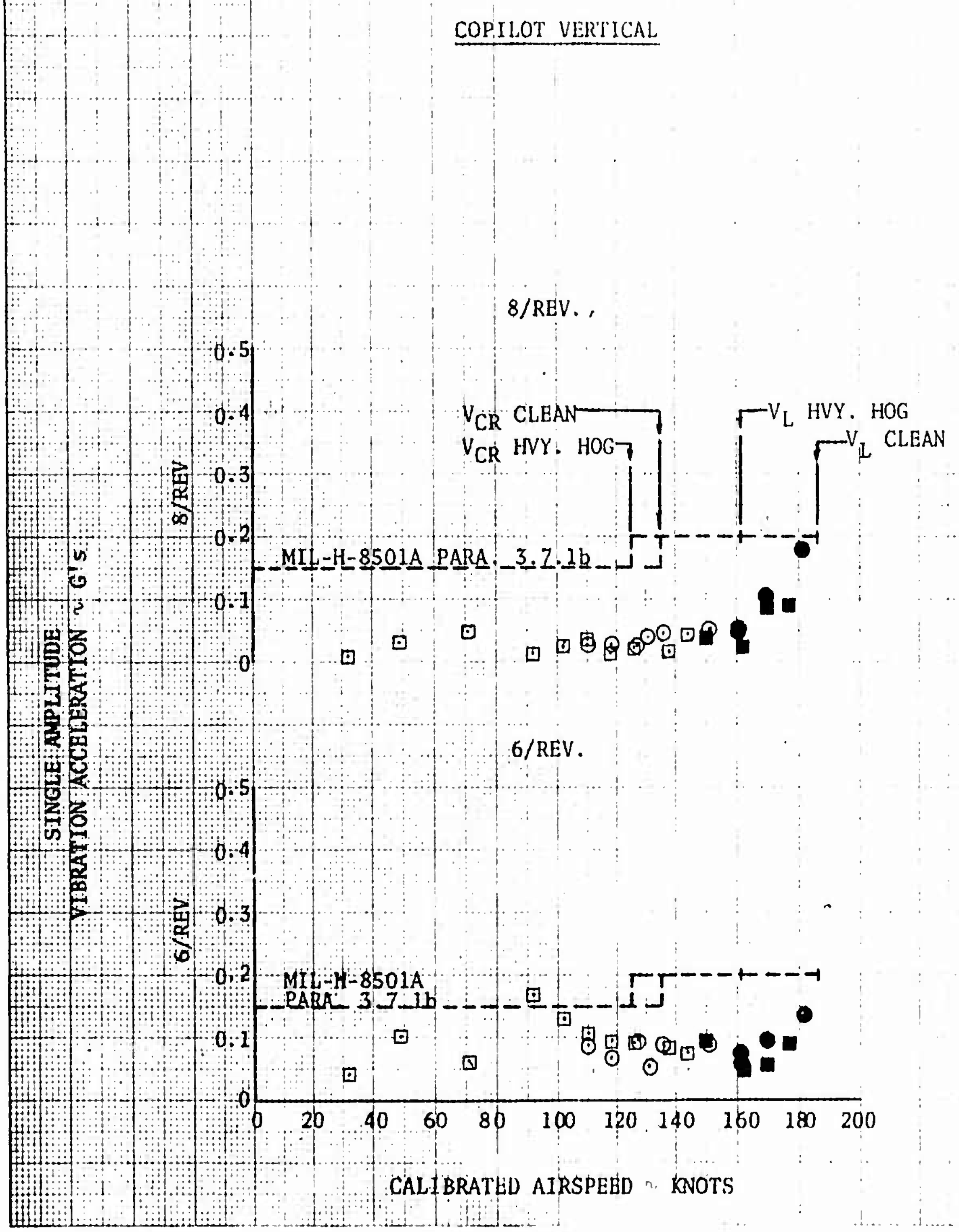
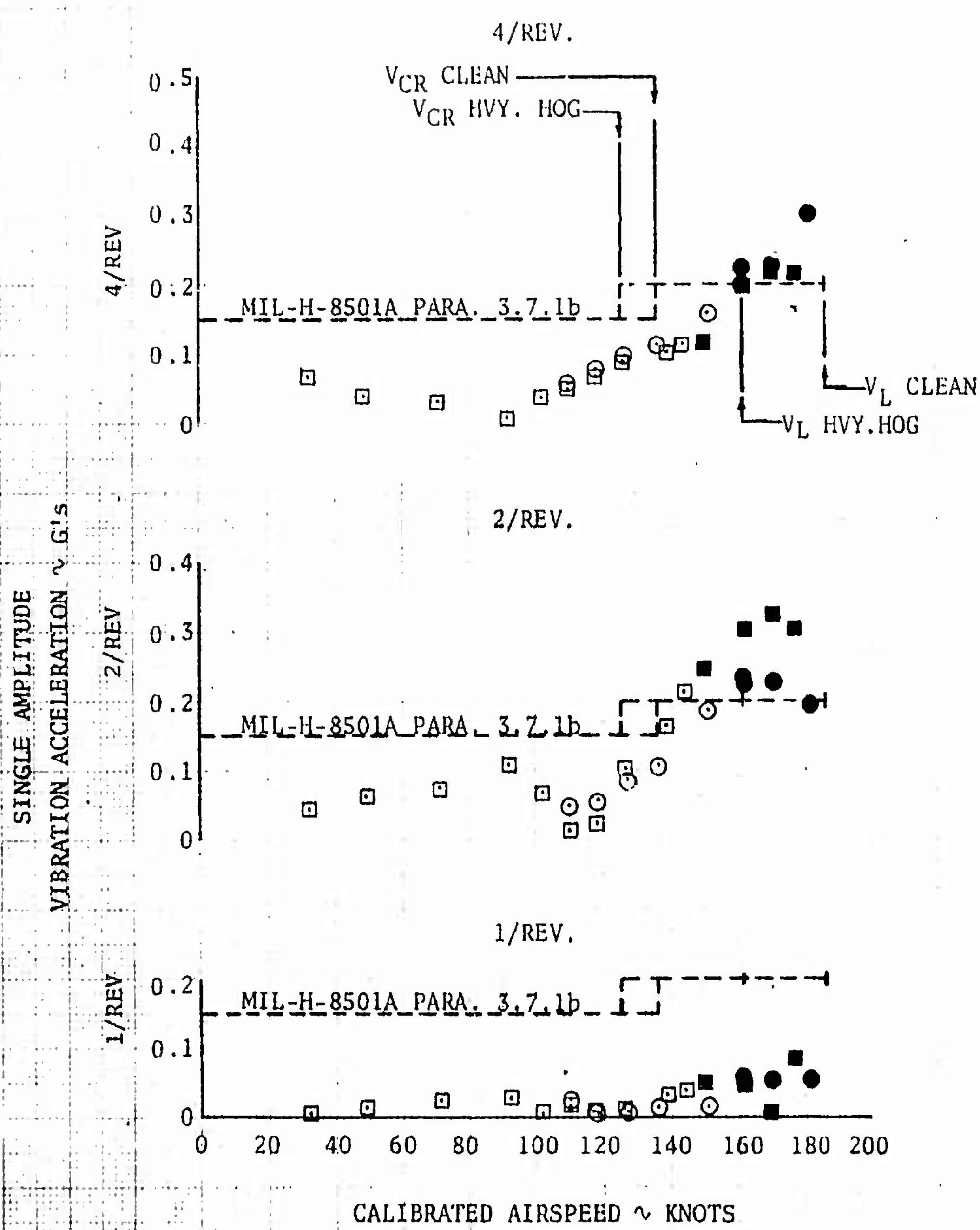


FIGURE NO. 9
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

SITE MOUNTING VERTICAL



SITE MOUNTING VERTICAL

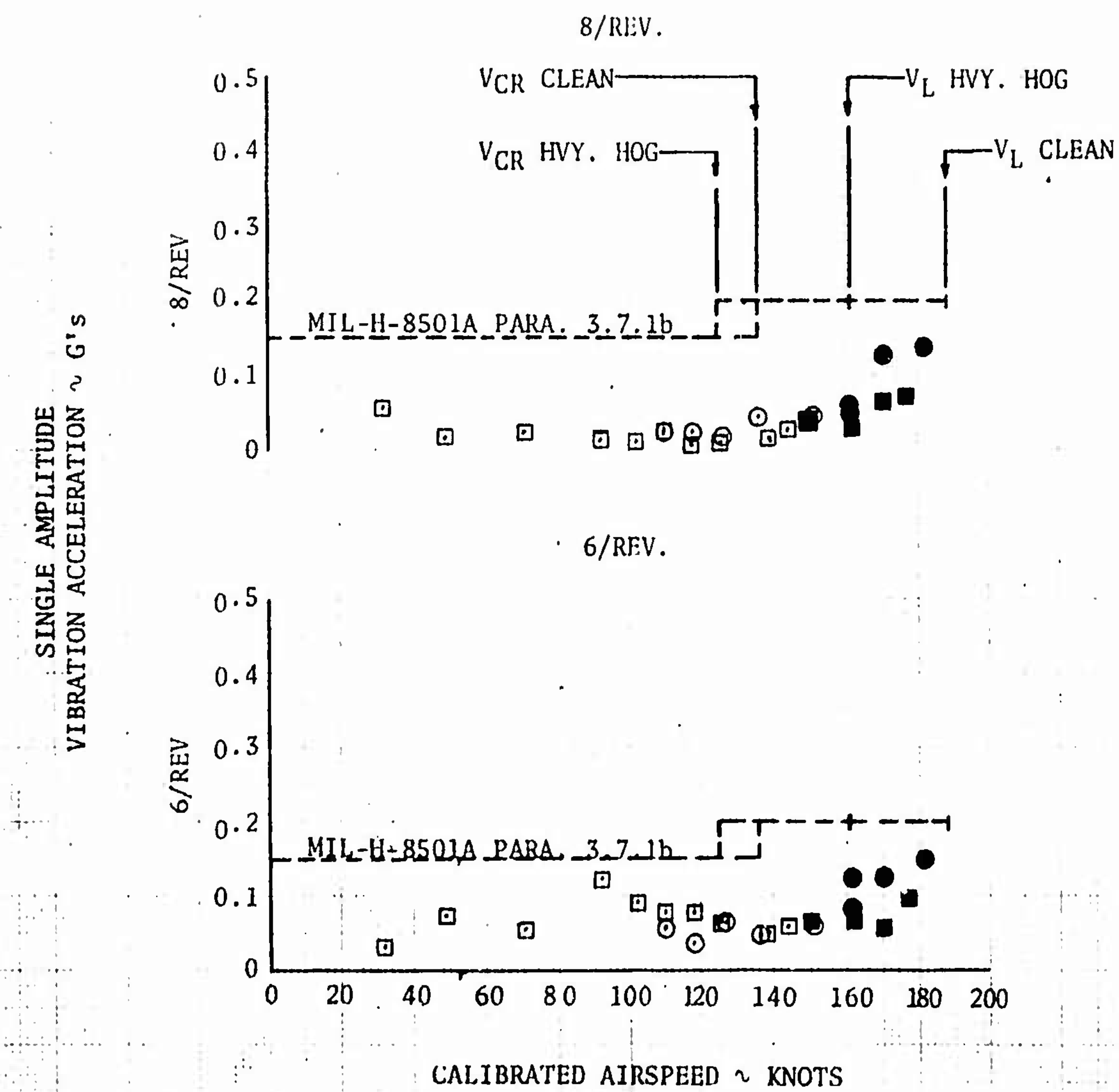


FIGURE NO. 10

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

PILOT LATERAL

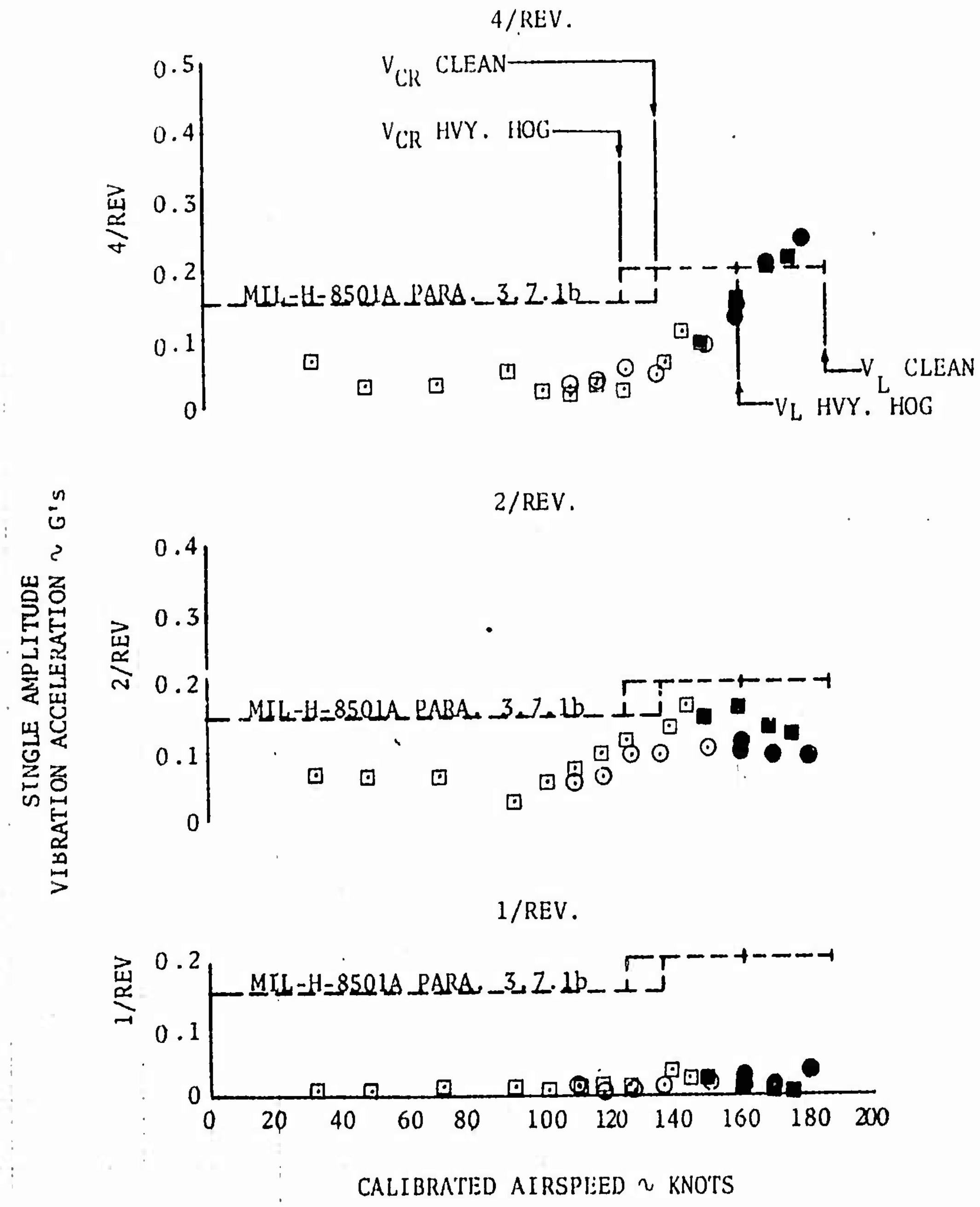


FIGURE NO. 10 CONTINUED

PILOT LATERAL

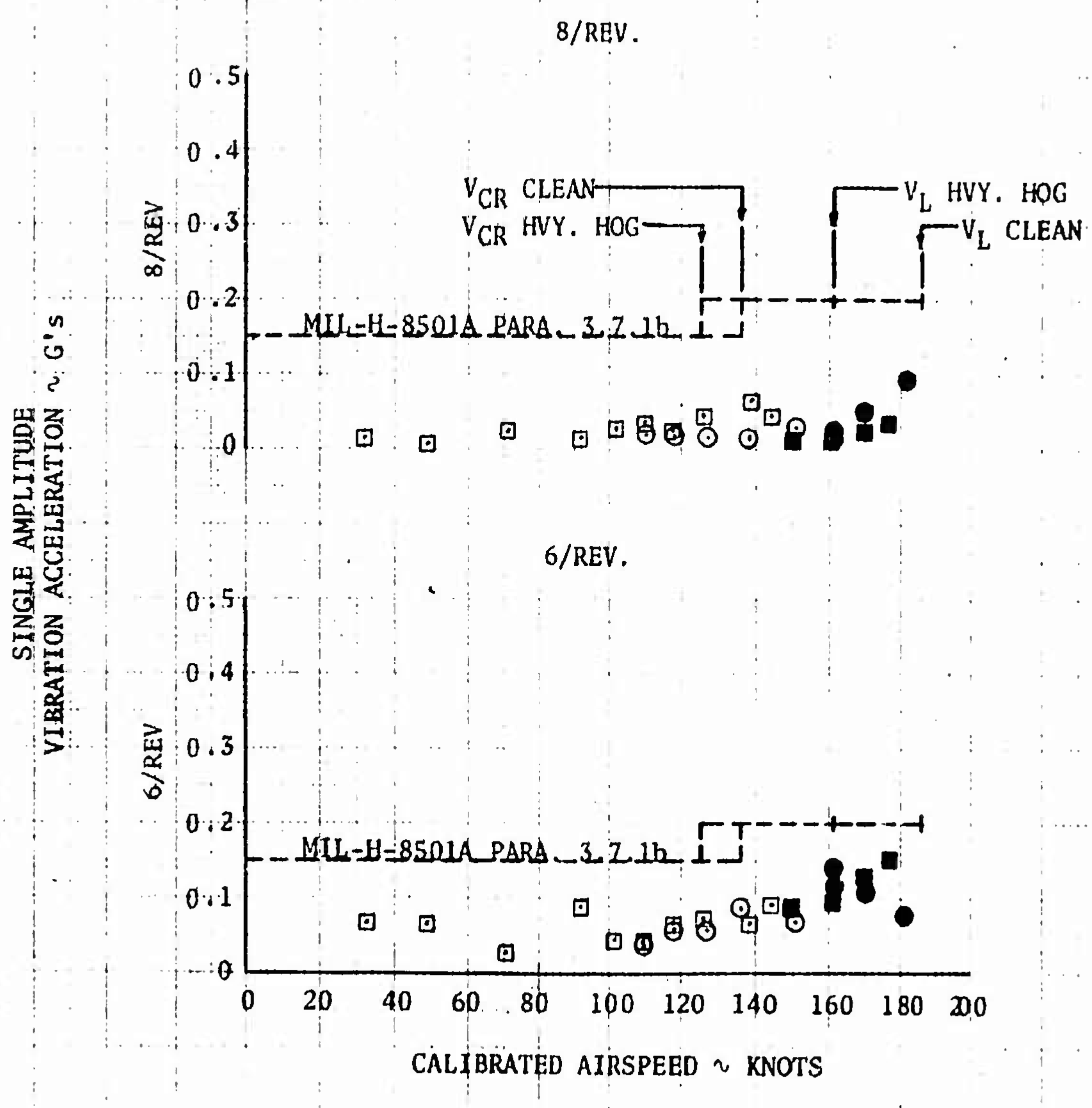


FIGURE NO. 11

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

COPILOT LATERAL

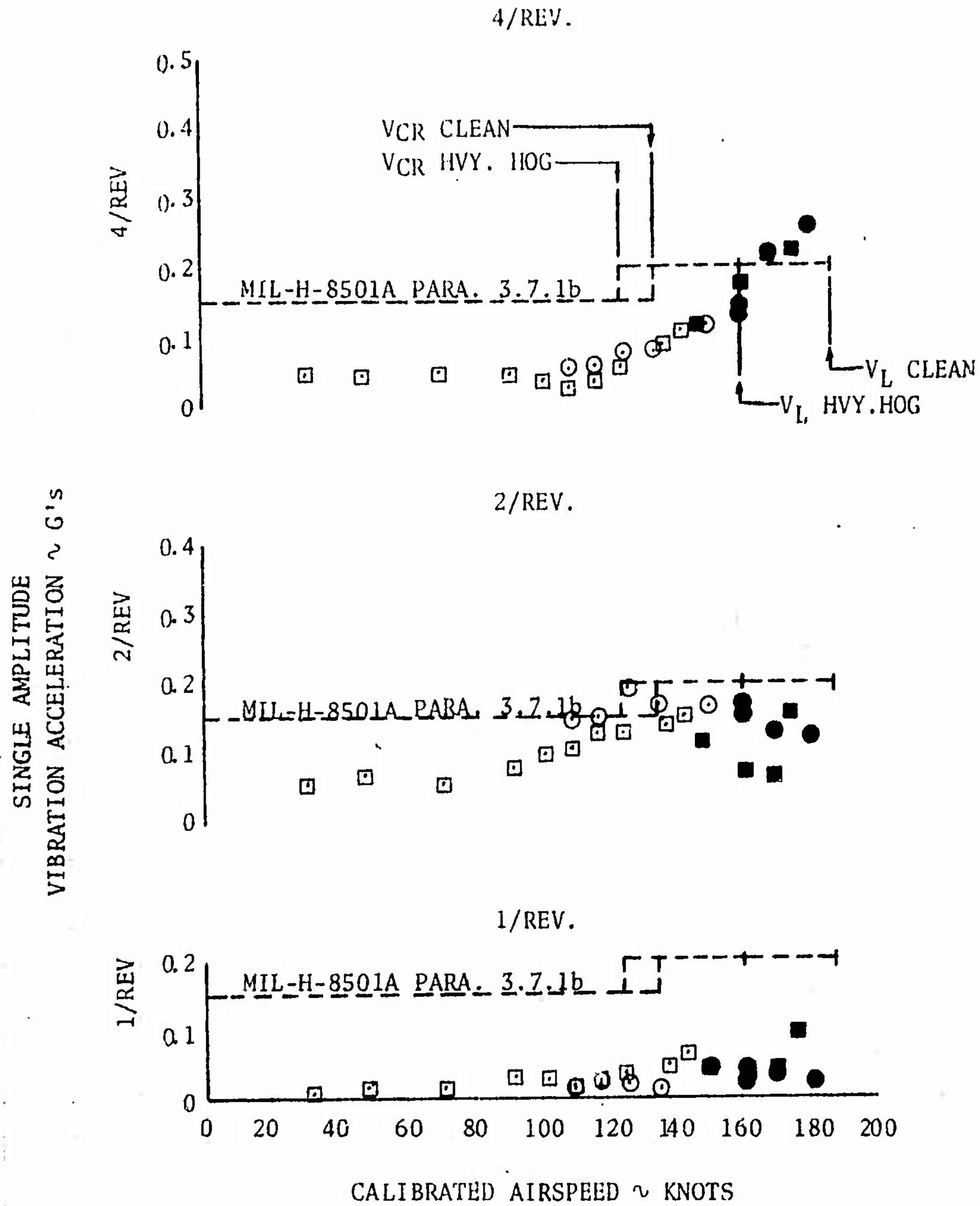


FIGURE NO. 11 CONTINUED

COPILOT LATERAL

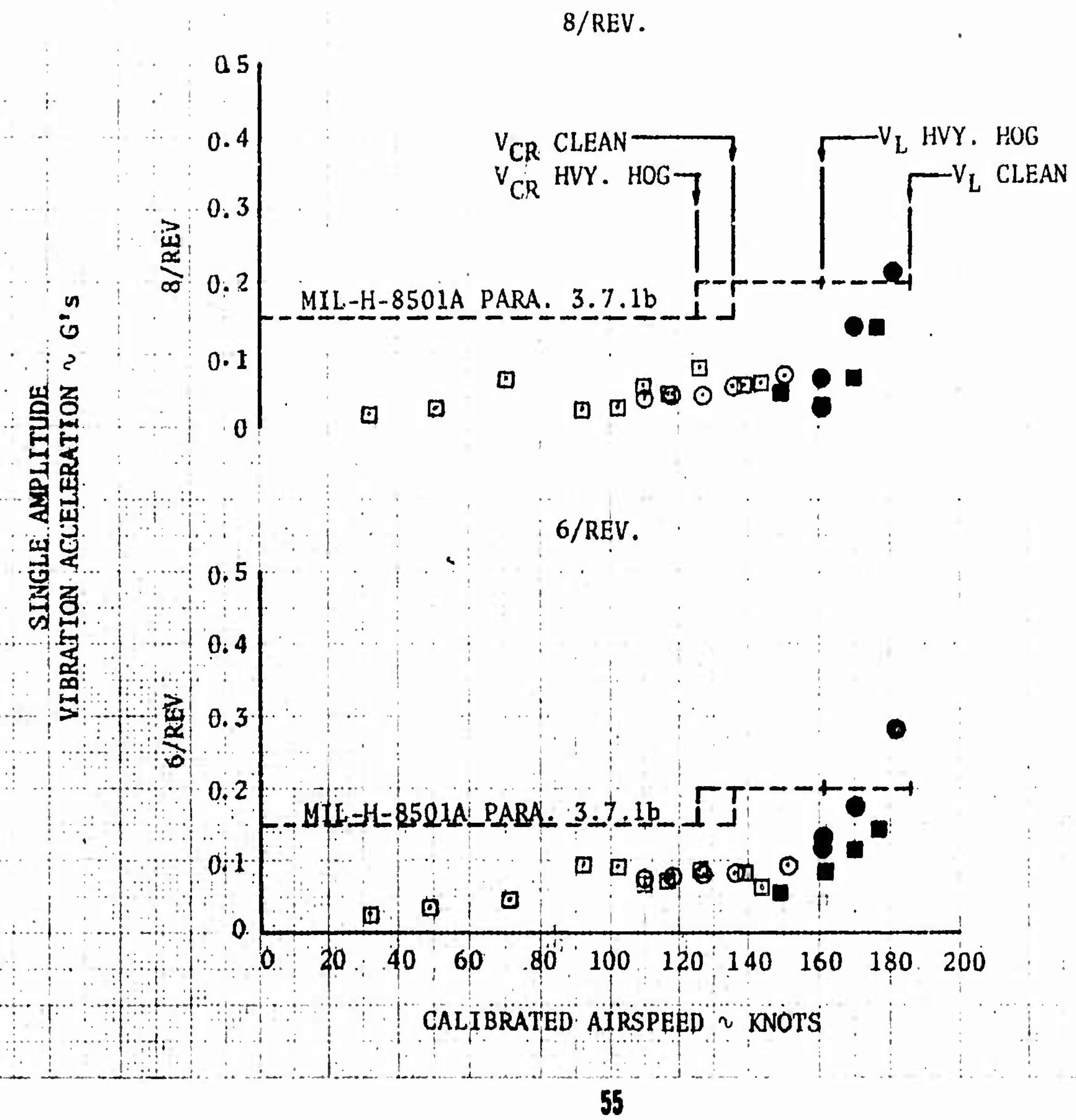


FIGURE NO. 12
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

SITE MOUNTING LATERAL

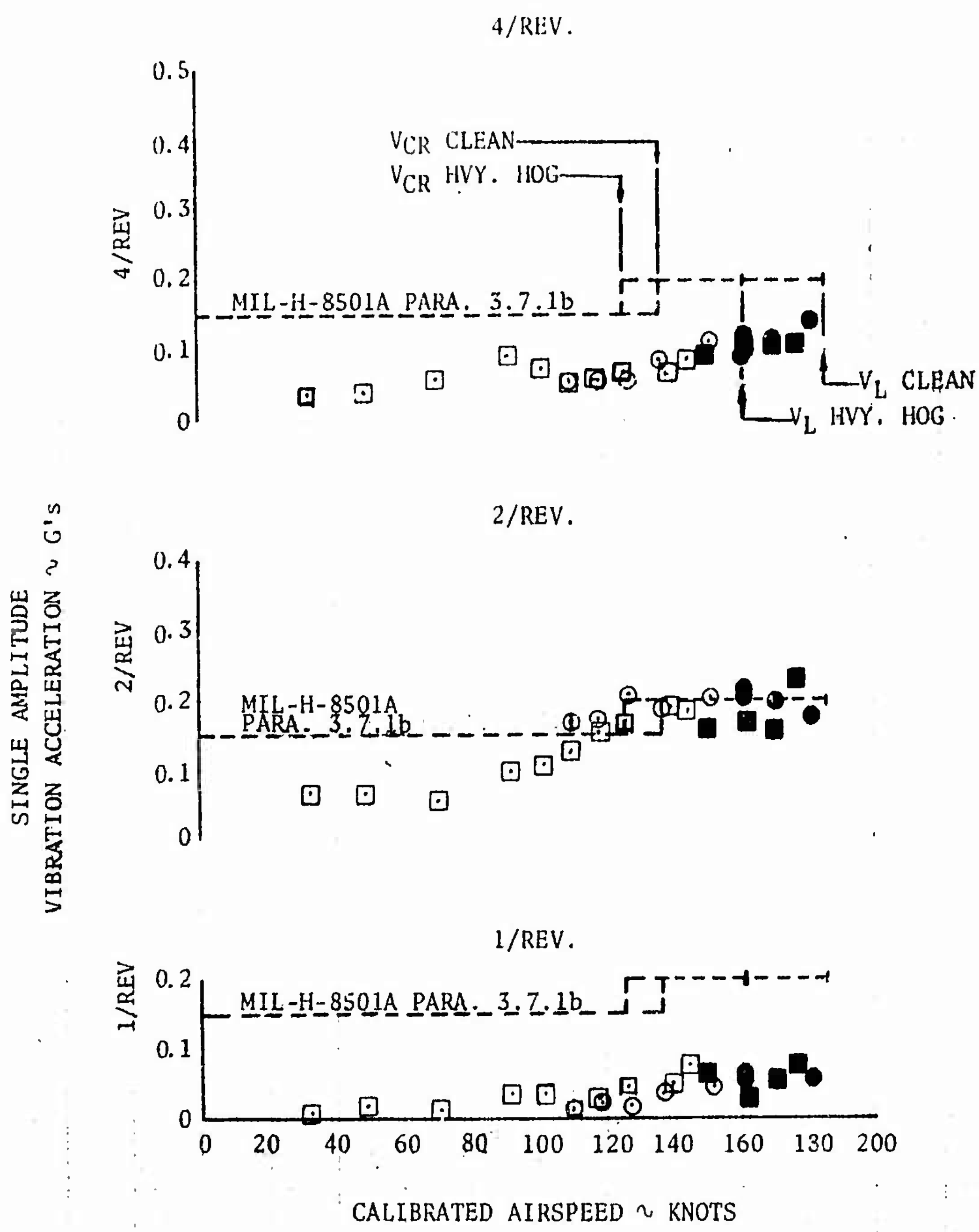


FIGURE NO. 12 CONTINUED

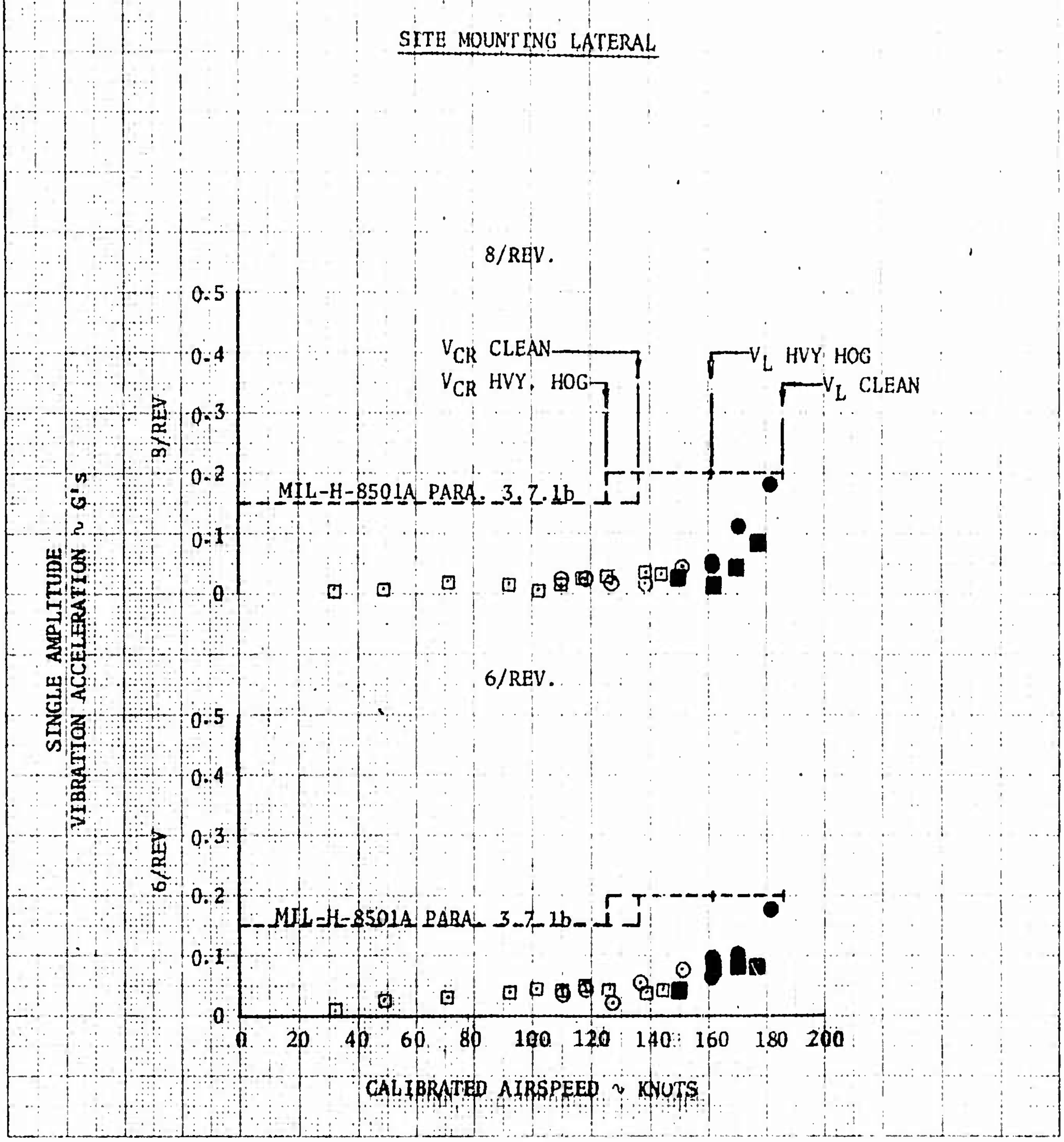


FIGURE NO. 13

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

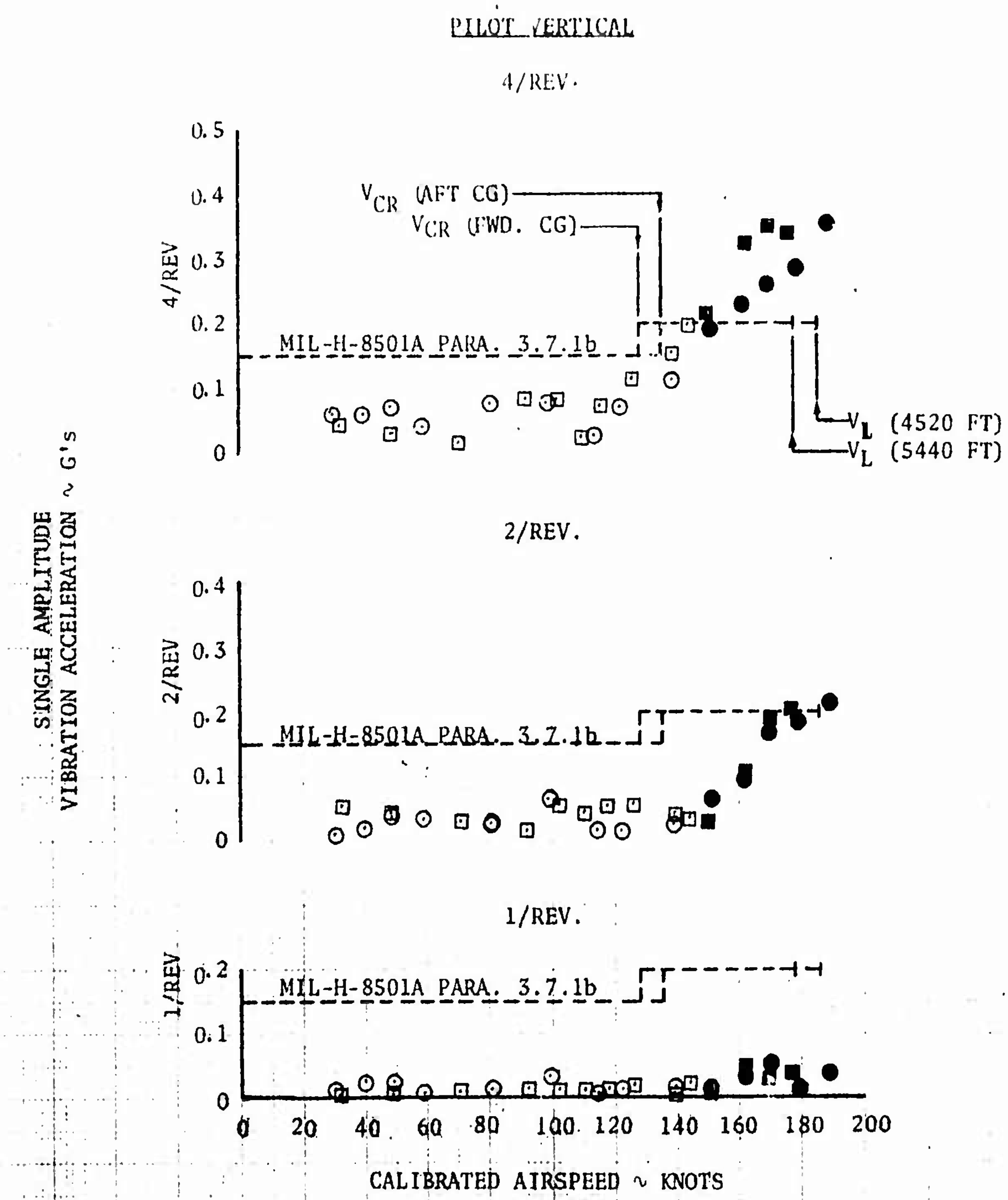


FIGURE NO. 13 CONTINUED

PILOT VERTICAL

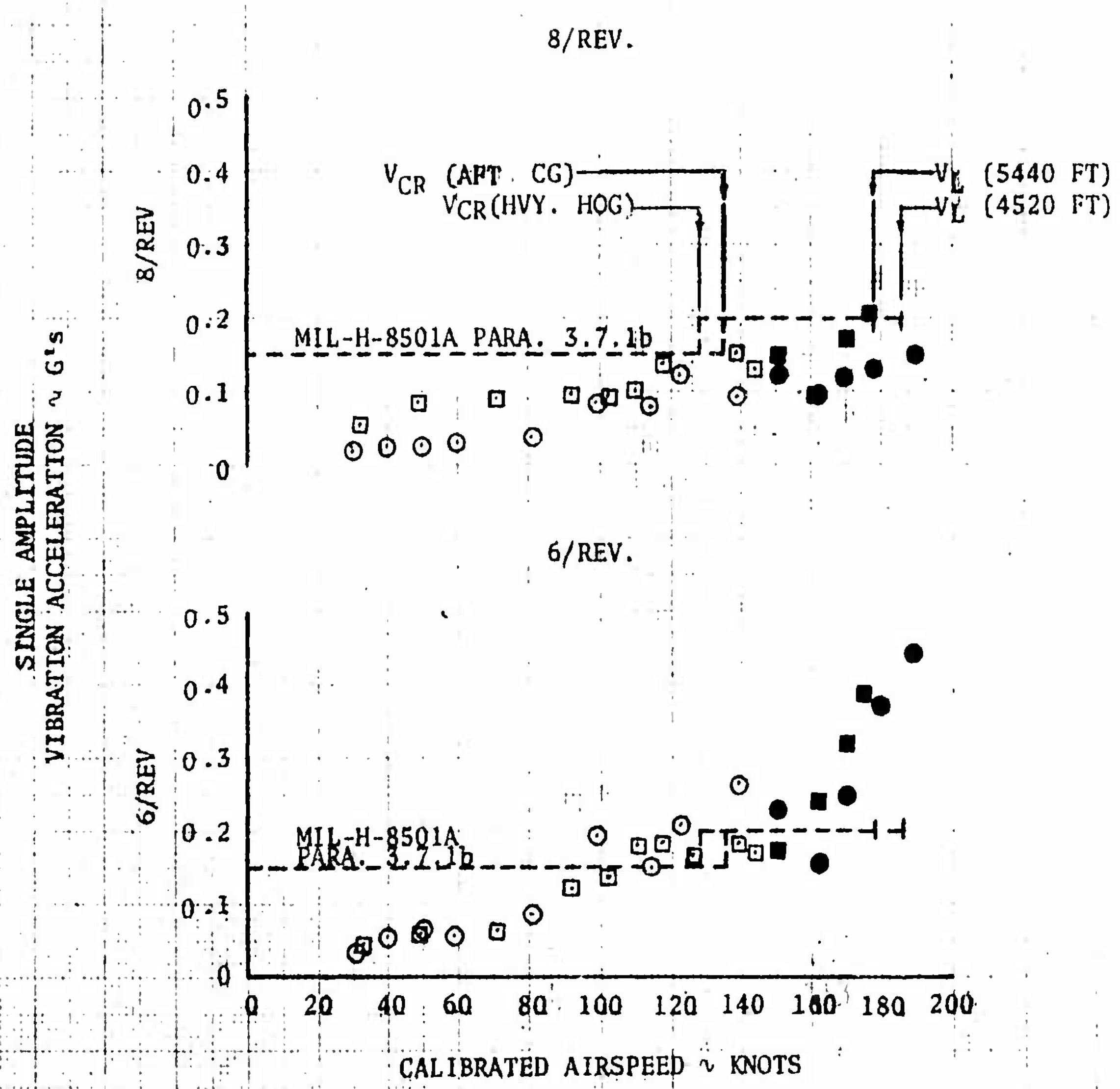
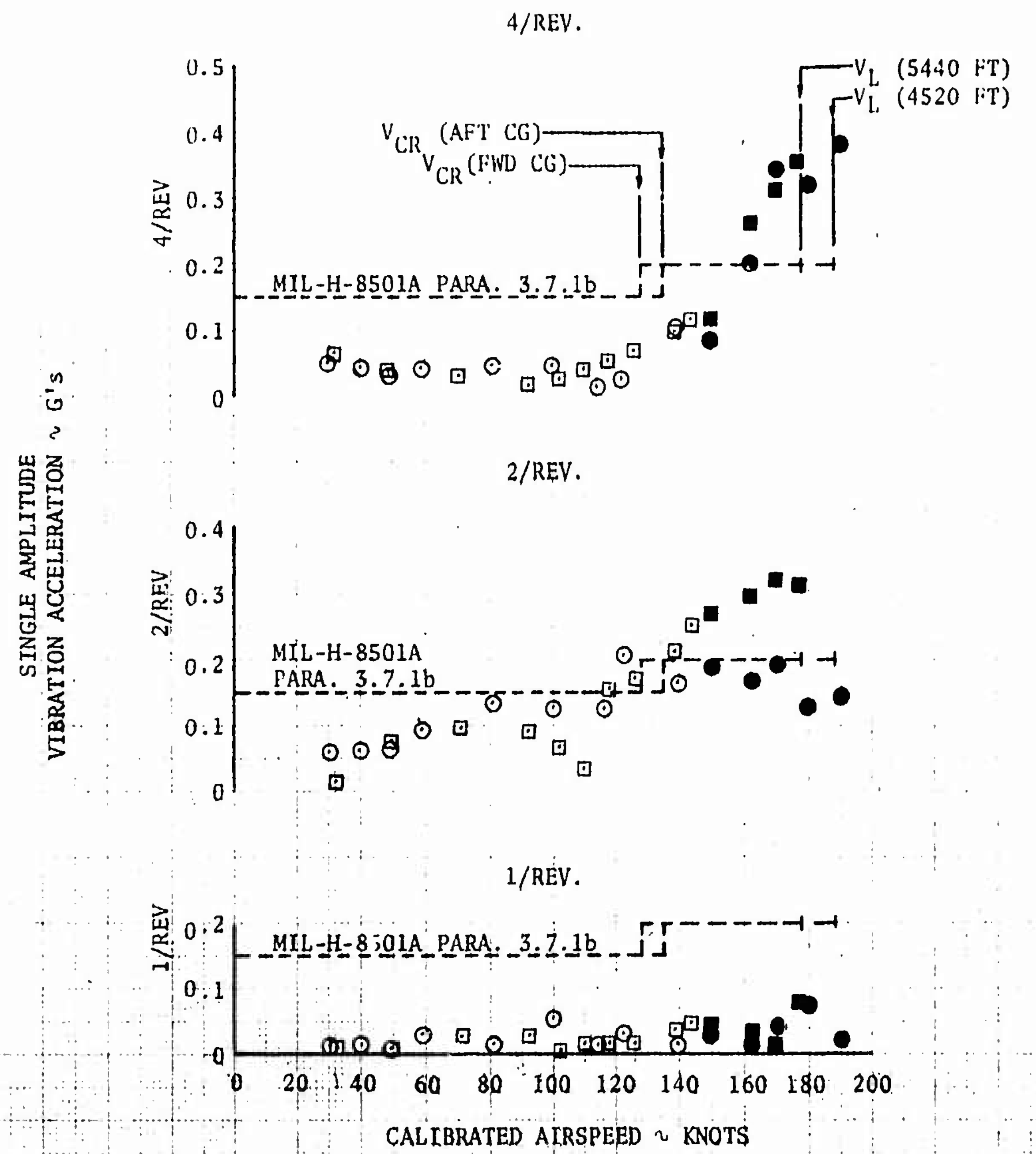


FIGURE NO. 14
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUND | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

COPILOT VERTICAL



COPILOT VERTICAL

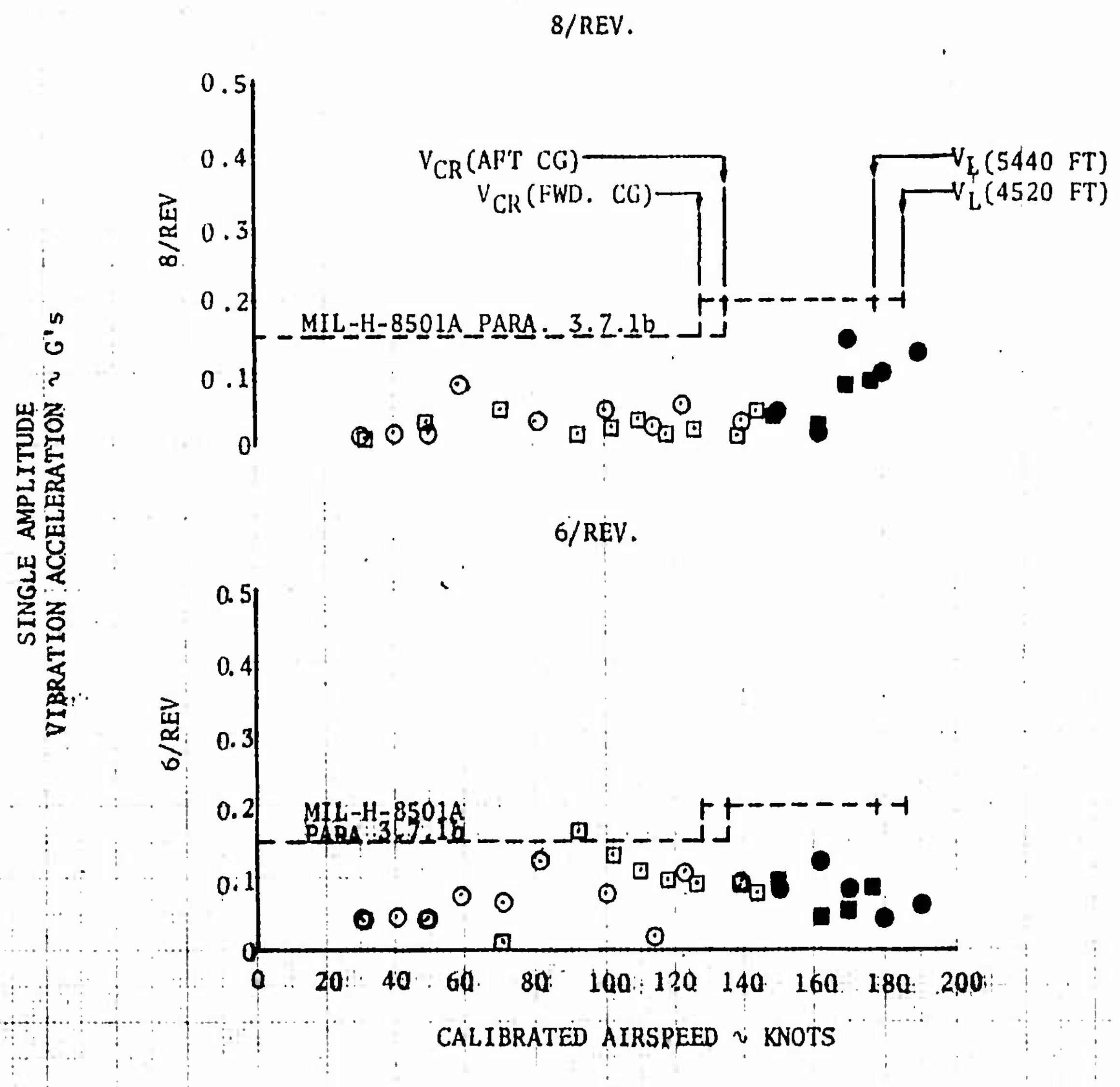


FIGURE NO. 15
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

SITE MOUNTING VERTICAL

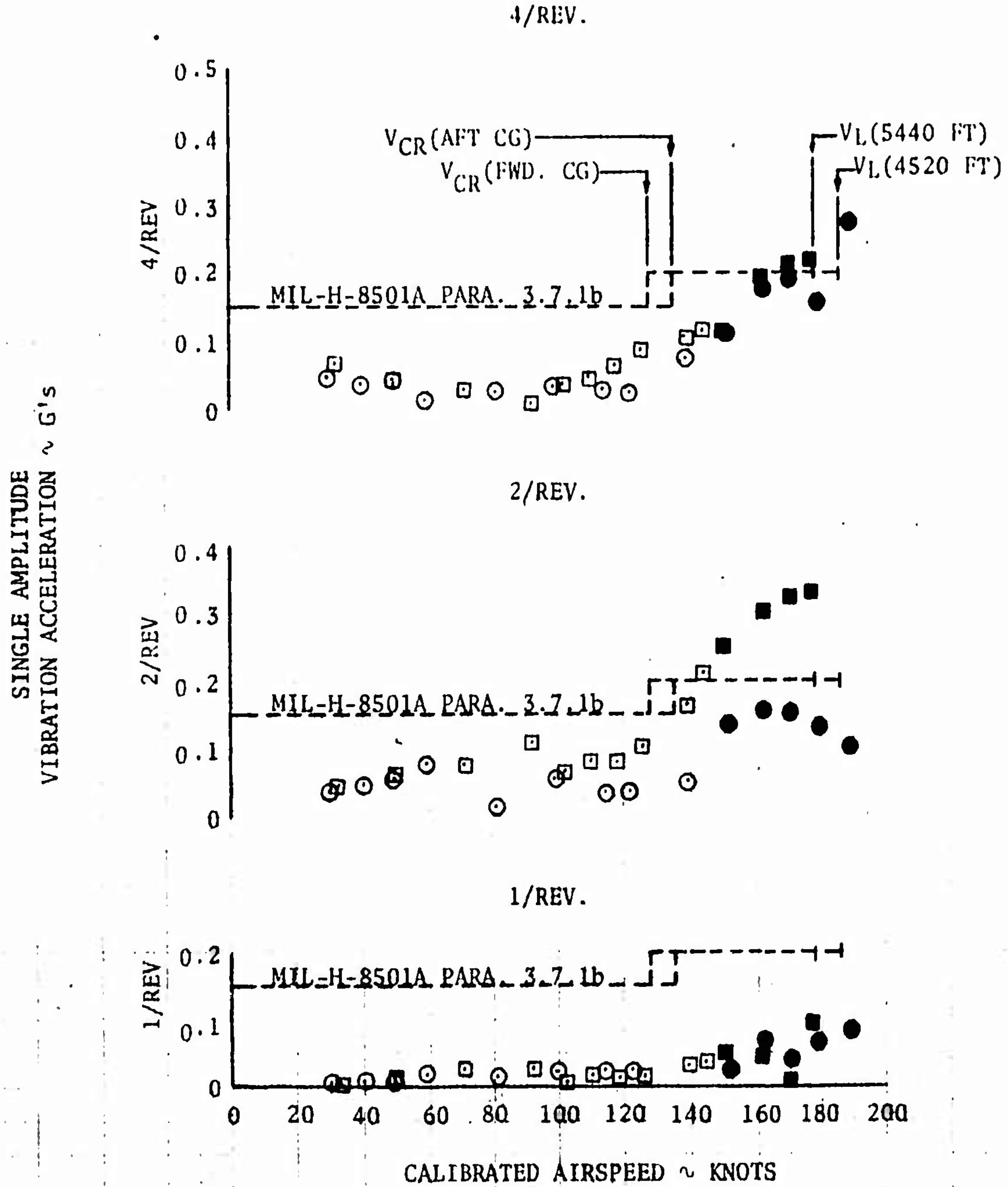


FIGURE NO. 15 CONTINUED

SITE MOUNTING VERTICAL

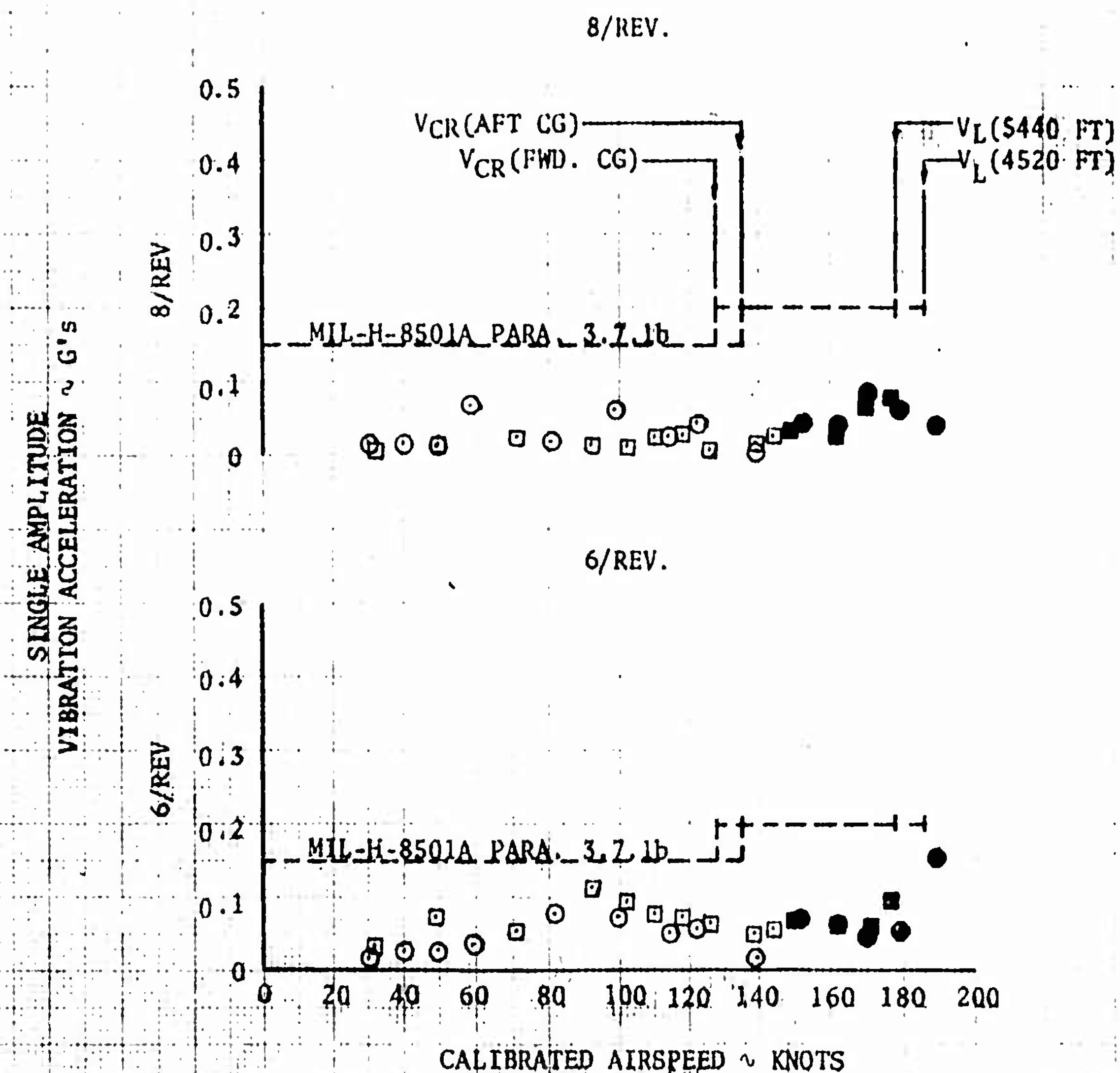


FIGURE NO. 16
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

PILOT LATERAL

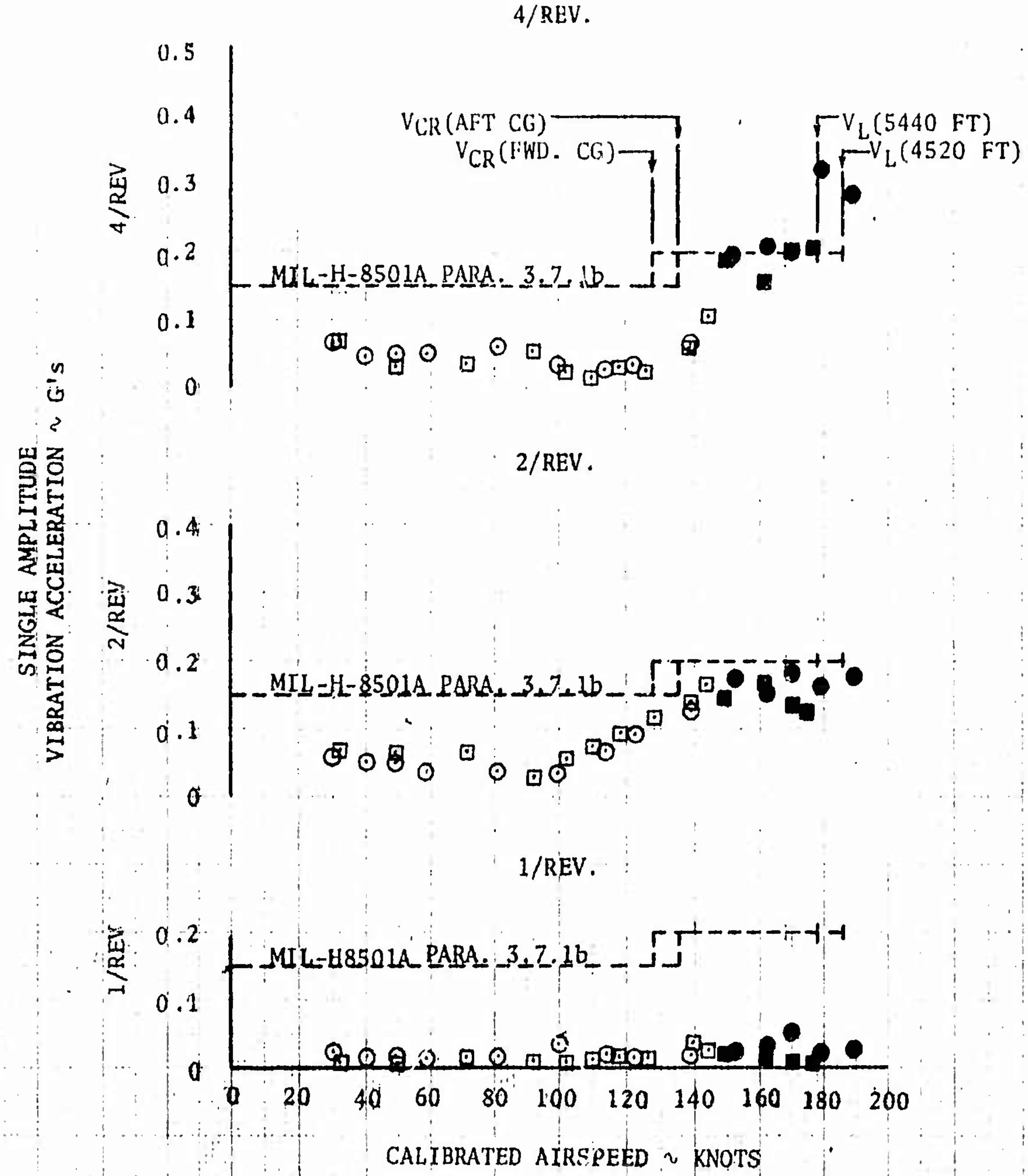


FIGURE NO. 16 CONTINUED

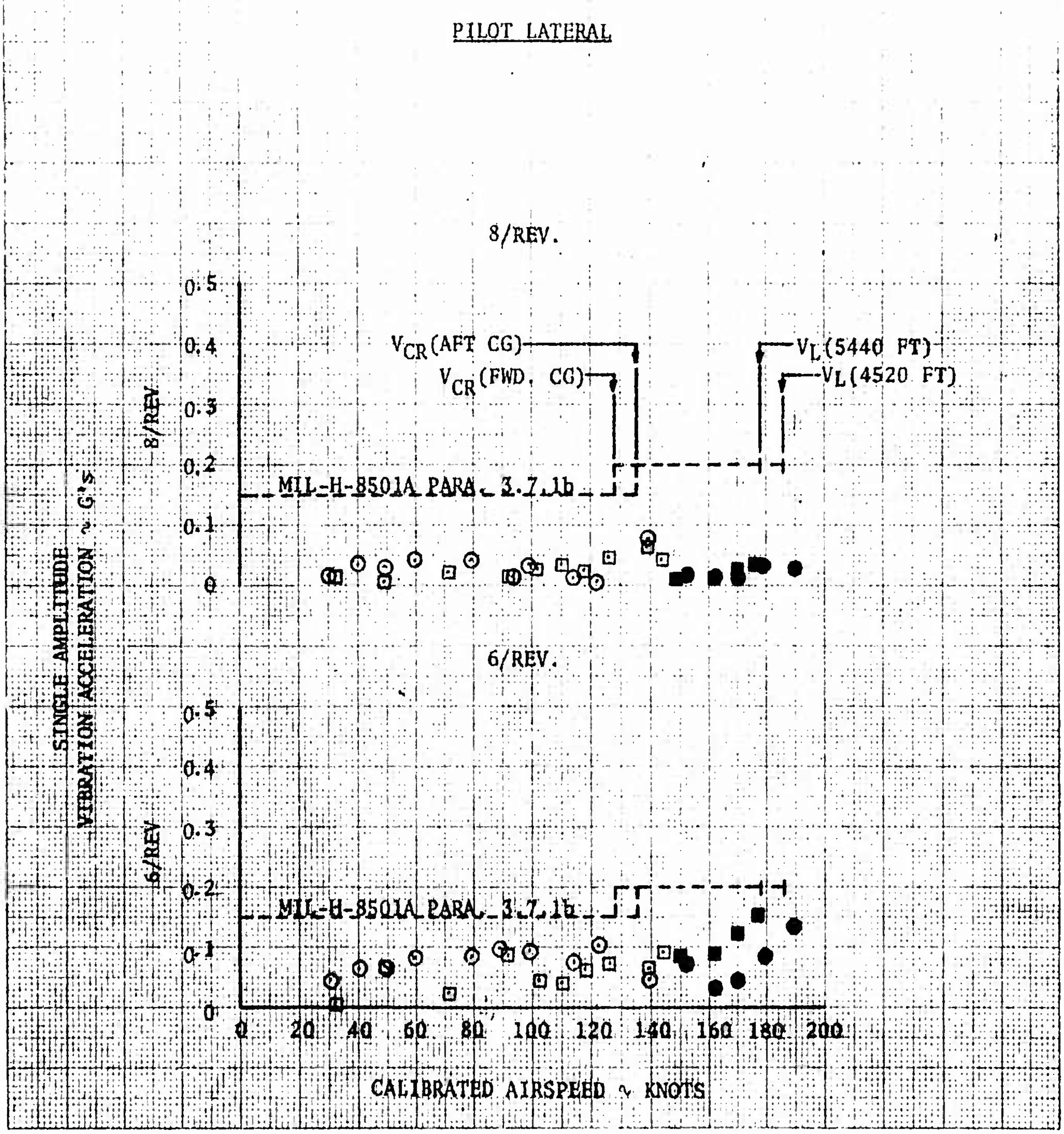


FIGURE NO. 17
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

COPILOT LATERAL

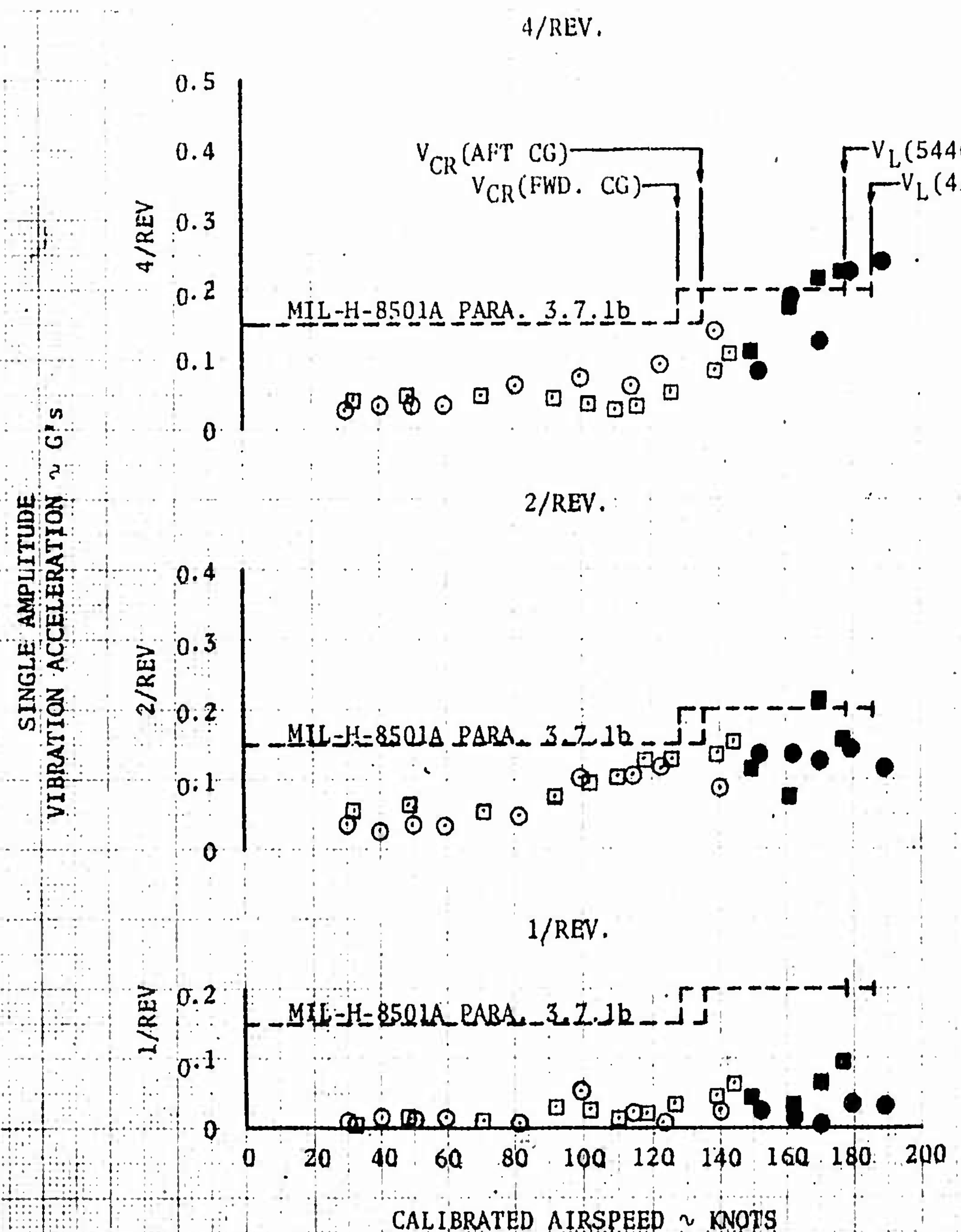


FIGURE NO. 17 CONTINUED

COPILOT LATERAL

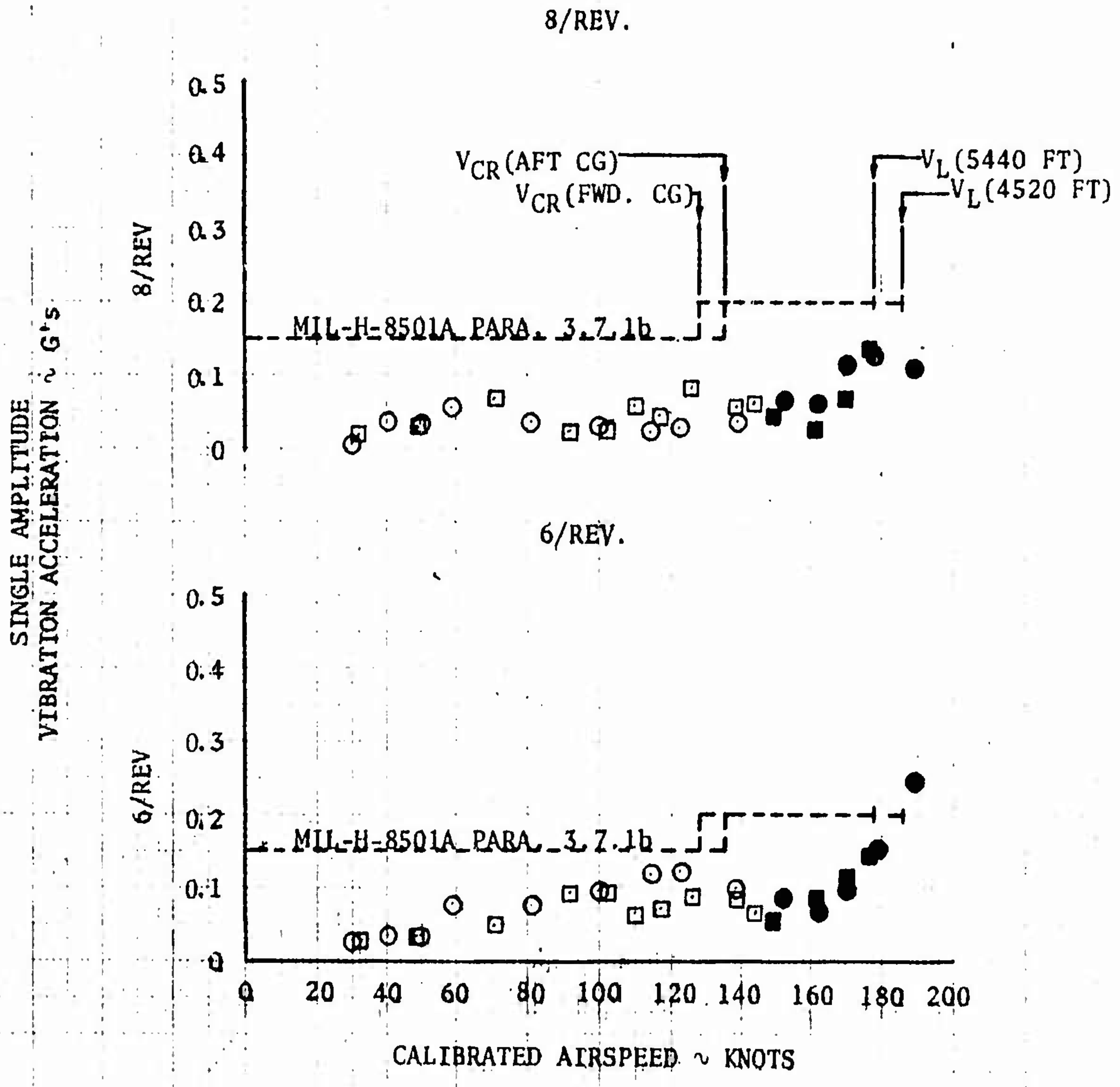
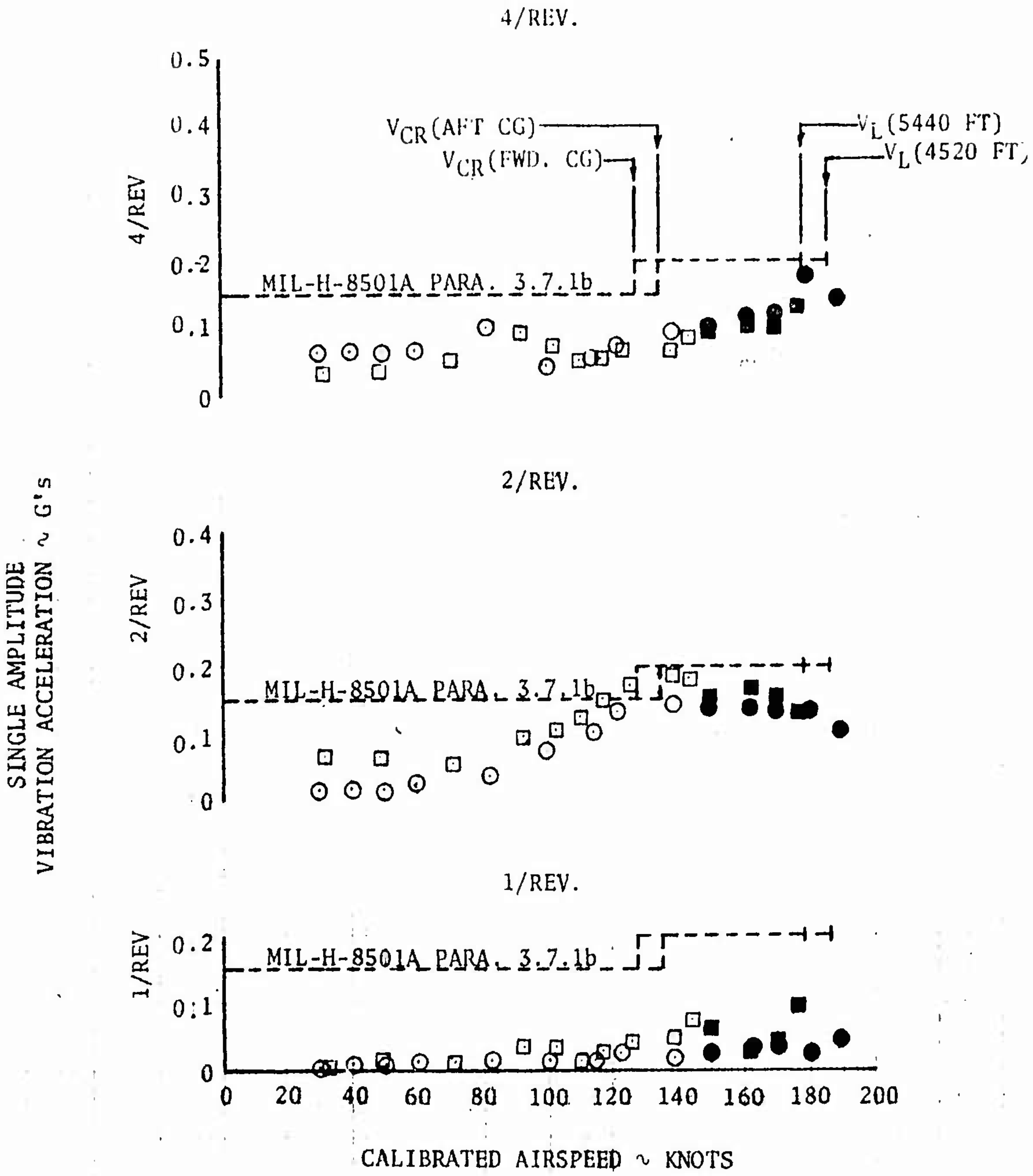


FIGURE NO. 18
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 8460 | 4540 | 324.0 | 201.6 (AFT) | CLEAN | LEVEL FLT. |
| ■ | 8315 | 4520 | 324.0 | 201.7 (AFT) | CLEAN | DIVE |

SITE MOUNTING LATERAL



SITE MOUNTING LATERAL

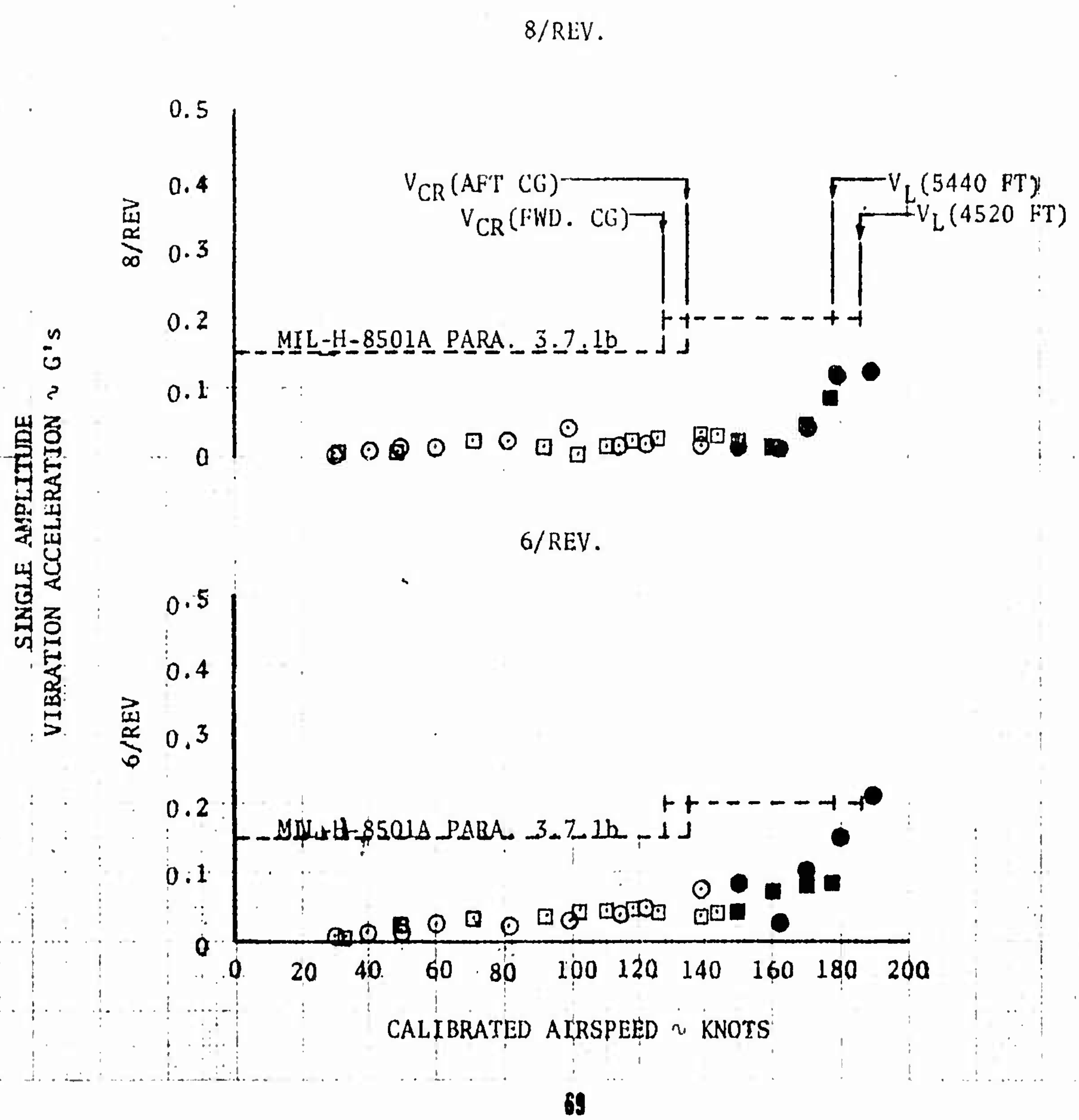


FIGURE NO. 19

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8170 | 4950 | 317.0 | 201.7 (AFT) | CLEAN | AUTO. |
| ● | 8170 | 4950 | 323.0 | 201.7 (AFT) | CLEAN | CLIMB |
| □ | 8220 | 6220 | 320.0 | 201.0 (AFT) | HVY HOG | AUTO. |
| ■ | 8230 | 6220 | 324.0 | 201.0 (AFT) | HVY HOG | CLIMB |

PILOT VERTICAL

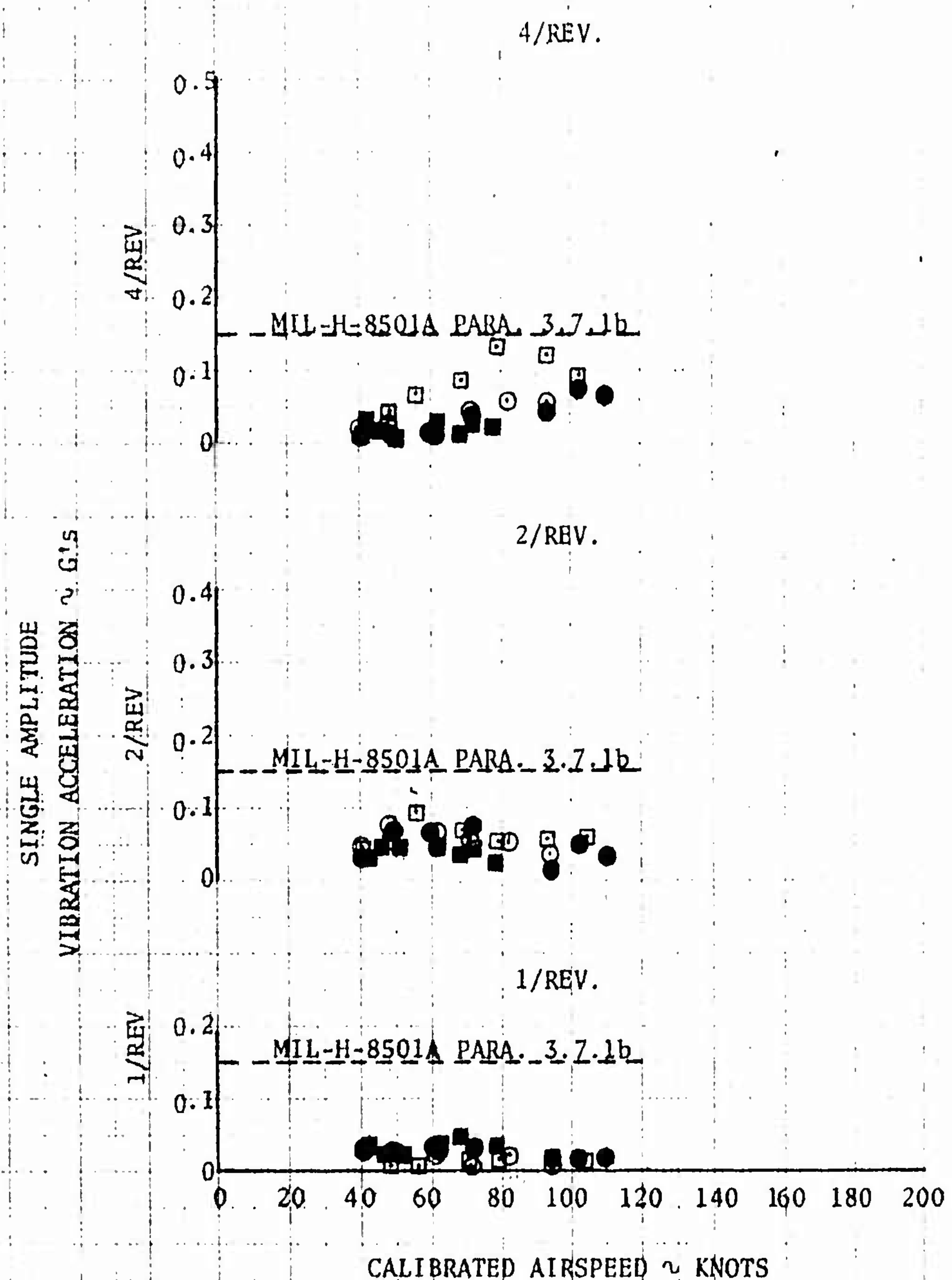


FIGURE NO. 19 CONTINUED

PILOT VERTICAL

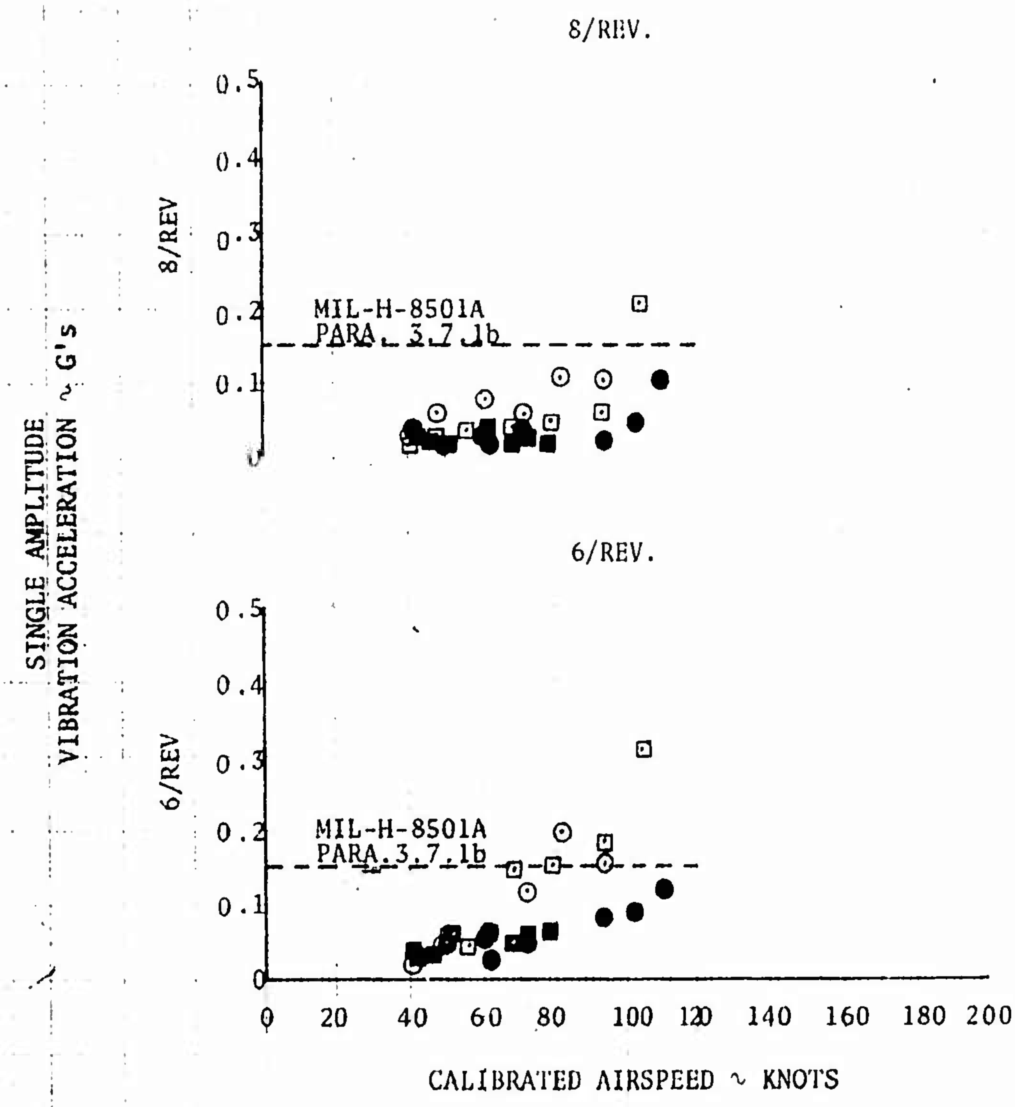
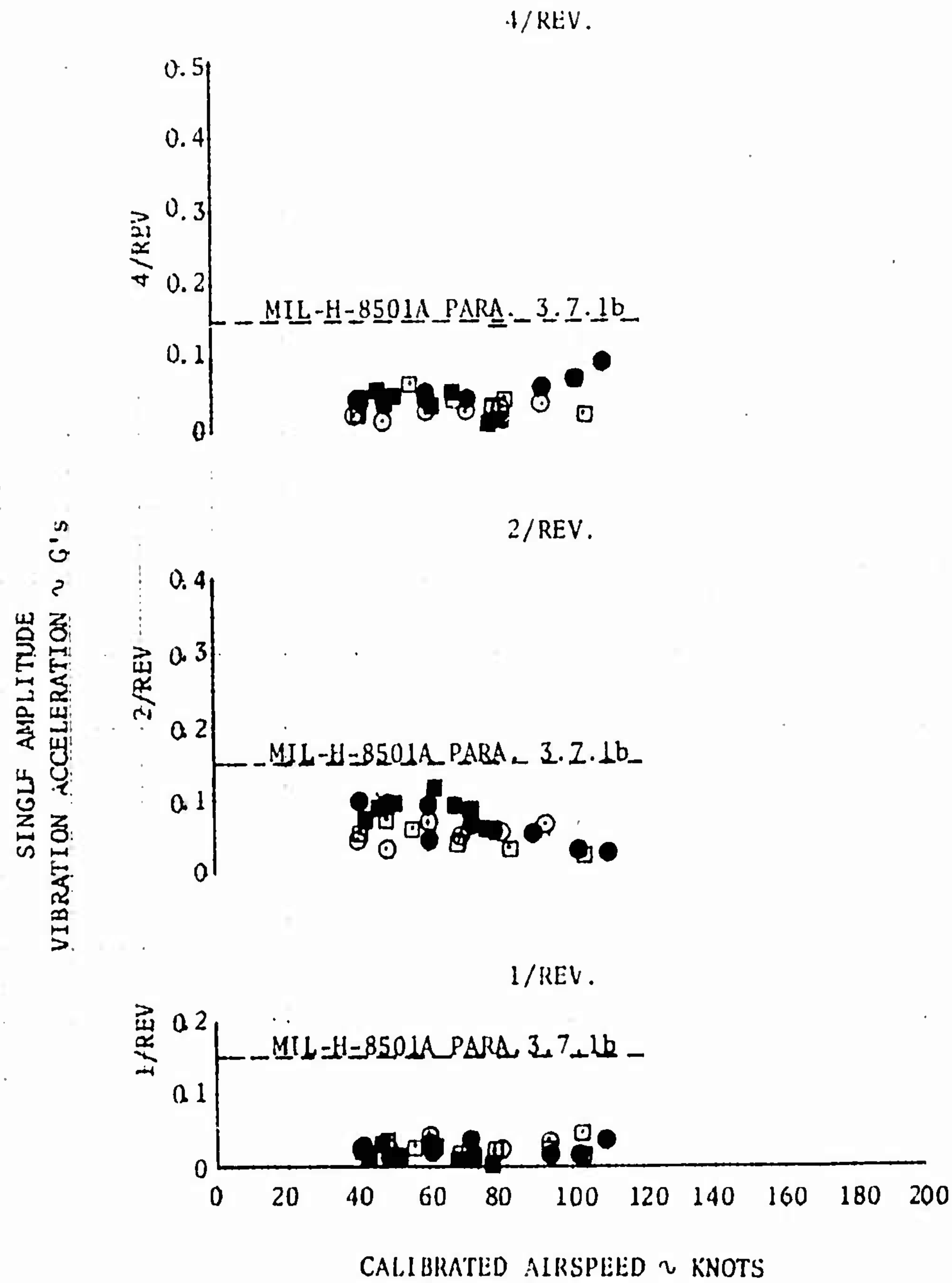


FIGURE NO. 20
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8170 | 4950 | 317.0 | 201.7 (AFT) | CLEAN | AUTO. |
| ● | 8170 | 4950 | 323.0 | 201.7 (AFT) | CLEAN | CLIMB |
| □ | 8220 | 6220 | 320.0 | 201.0 (AFT) | HVY HOG | AUTO. |
| ■ | 8220 | 6220 | 324.0 | 201.0 (AFT) | HVY HOG | CLIMB |

COPILOT VERTICAL



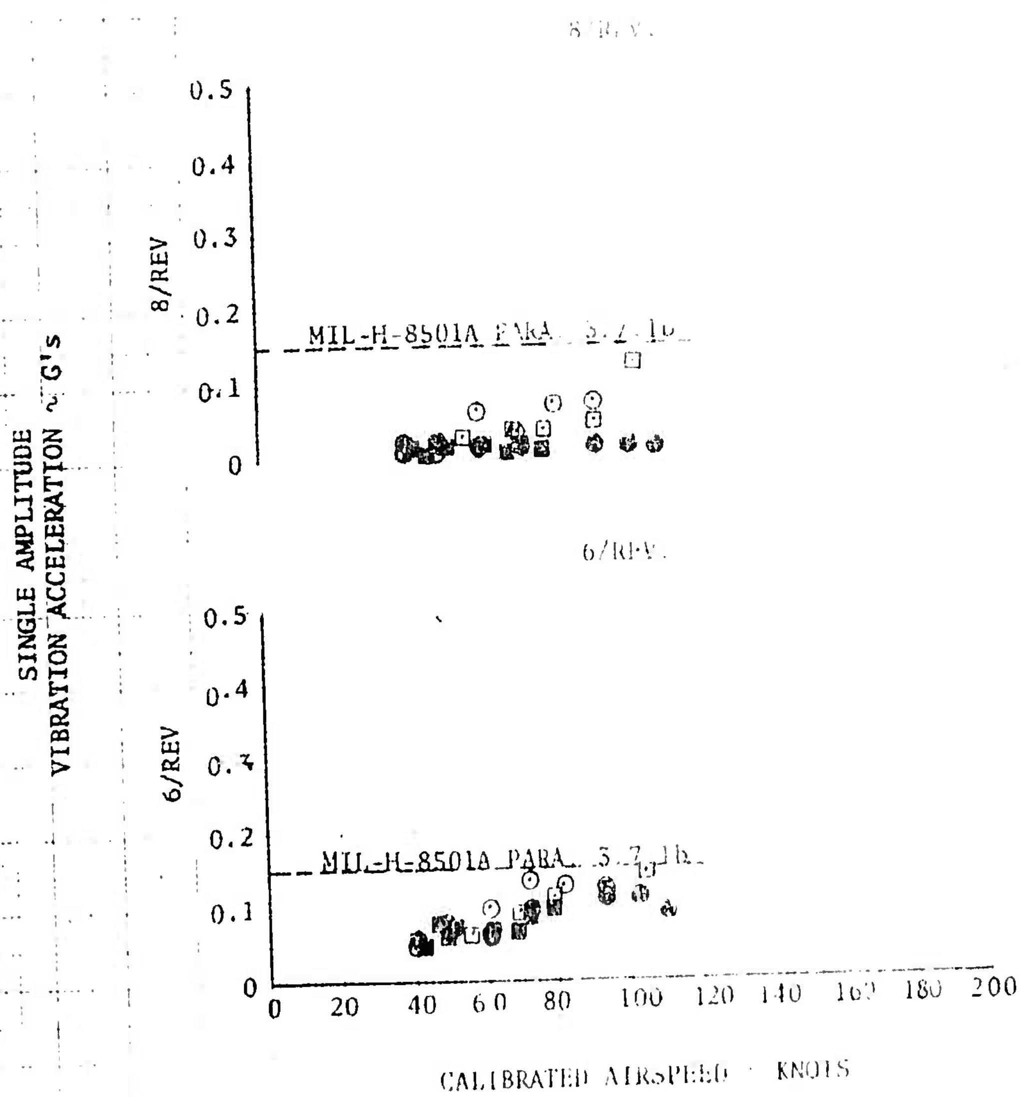

8/REV.
SINGLE AMPLITUDE
VIBRATION ACCELERATION ~ G's
8/REV
0.5
0.4
0.3
0.2
0.1
0
MIL-H-8501A PARA. 3.7.1b
6/REV.
6/REV
MIL-H-8501A PARA. 3.7.1b
0
20
40
60
80
100
120
140
160
180
200
CALIBRATED AIRSPEED ~ KNOTS

FIGURE NO. 21
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8170 | 4950 | 317.0 | 201.7 (AFT) | CLEAN | AUTO. |
| ● | 8170 | 4950 | 323.0 | 201.7 (AFT) | CLEAN | CLIMB |
| □ | 8220 | 6220 | 320.0 | 201.0 (AFT) | HVY HOG | AUTO. |
| ■ | 8220 | 6220 | 324.0 | 201.0 (AFT) | HVY HOG | CLIMB |

SITE MOUNTING VERTICAL

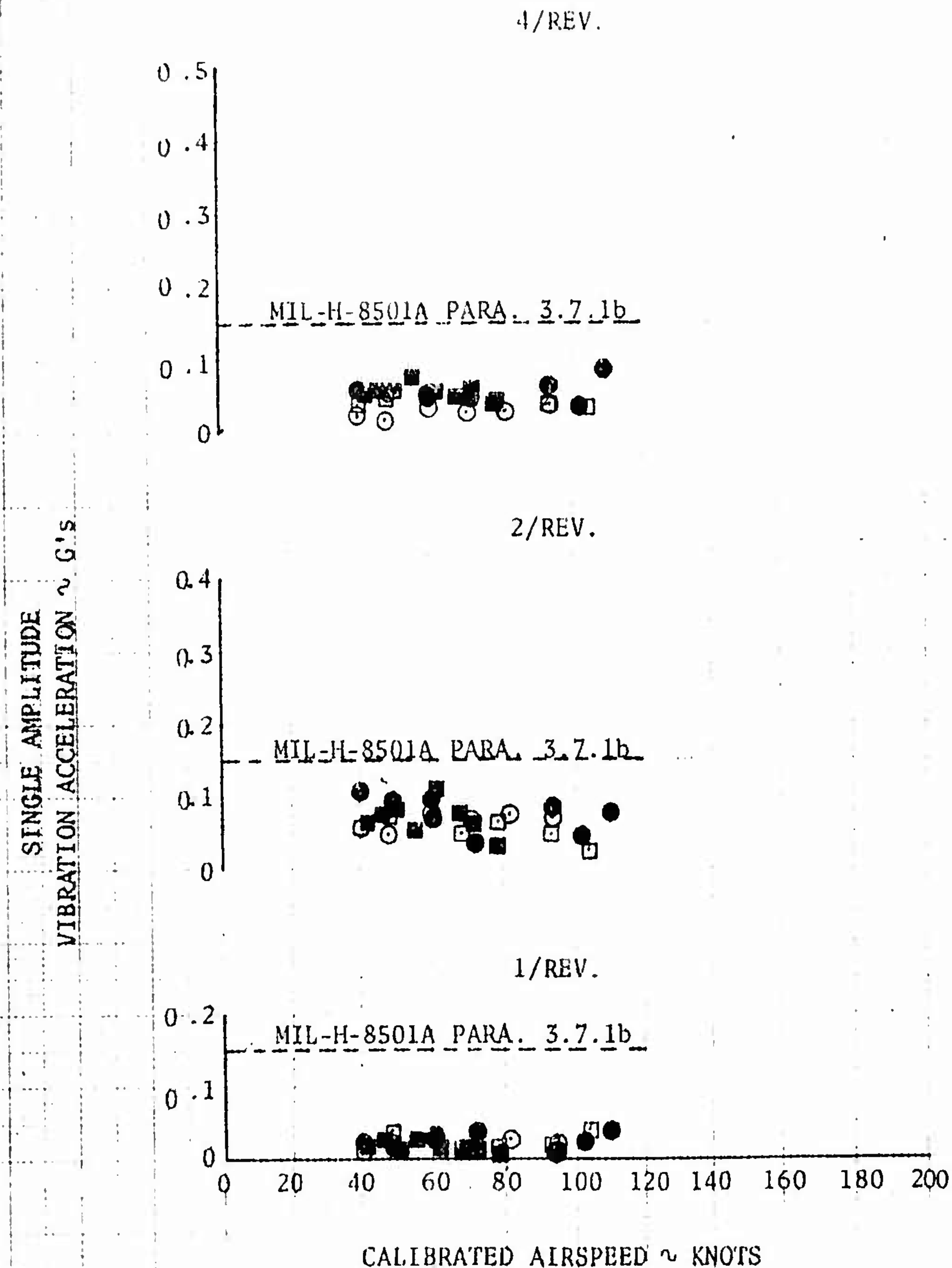


FIGURE NO. 21 CONTINUED

SITE MOUNTING VERTICAL

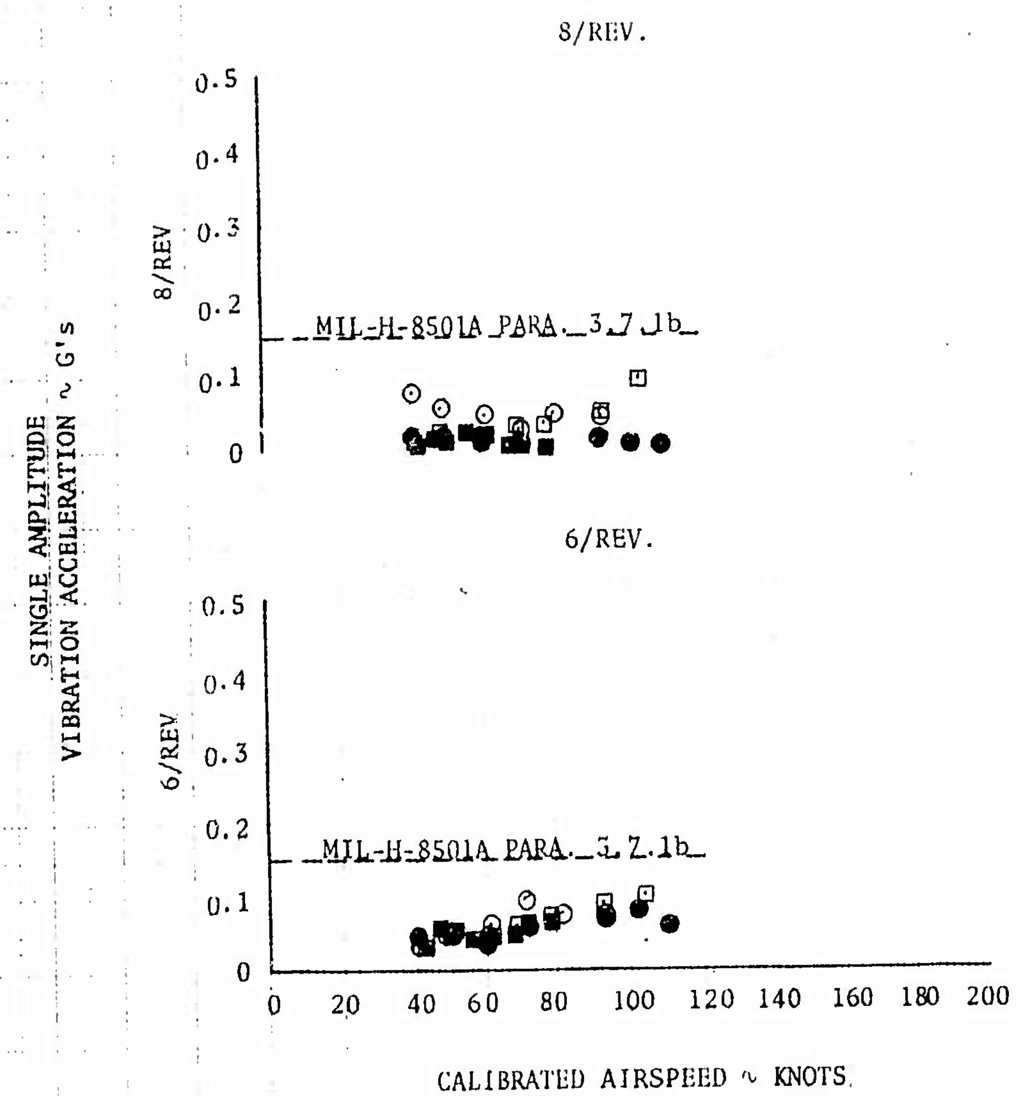


FIGURE NO 22
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8170 | 4950 | 317.0 | 201.7 (AFT) | CLEAN | AUTO.. |
| ● | 8170 | 4950 | 323.0 | 201.7 (AFT) | CLEAN | CLIMB |
| □ | 8220 | 6220 | 320.0 | 201.0 (AFT) | HVY HOG | AUTO. |
| ■ | 8220 | 6220 | 324.0 | 201.0 (AFT) | HVY HOG | CLIMB |

PILOT LATERAL

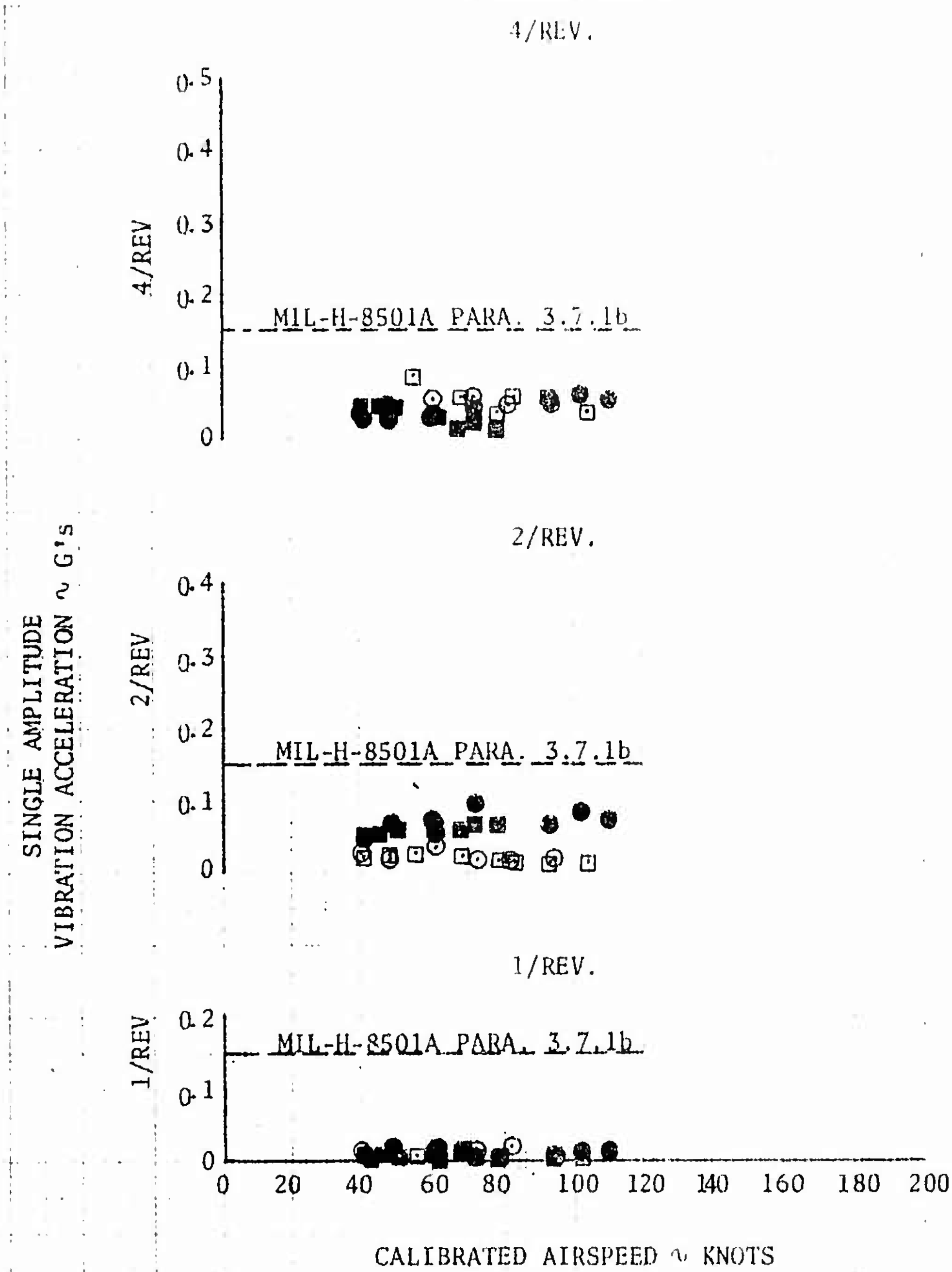


FIGURE NO. 22 CONTINUED

PILOT LATERAL

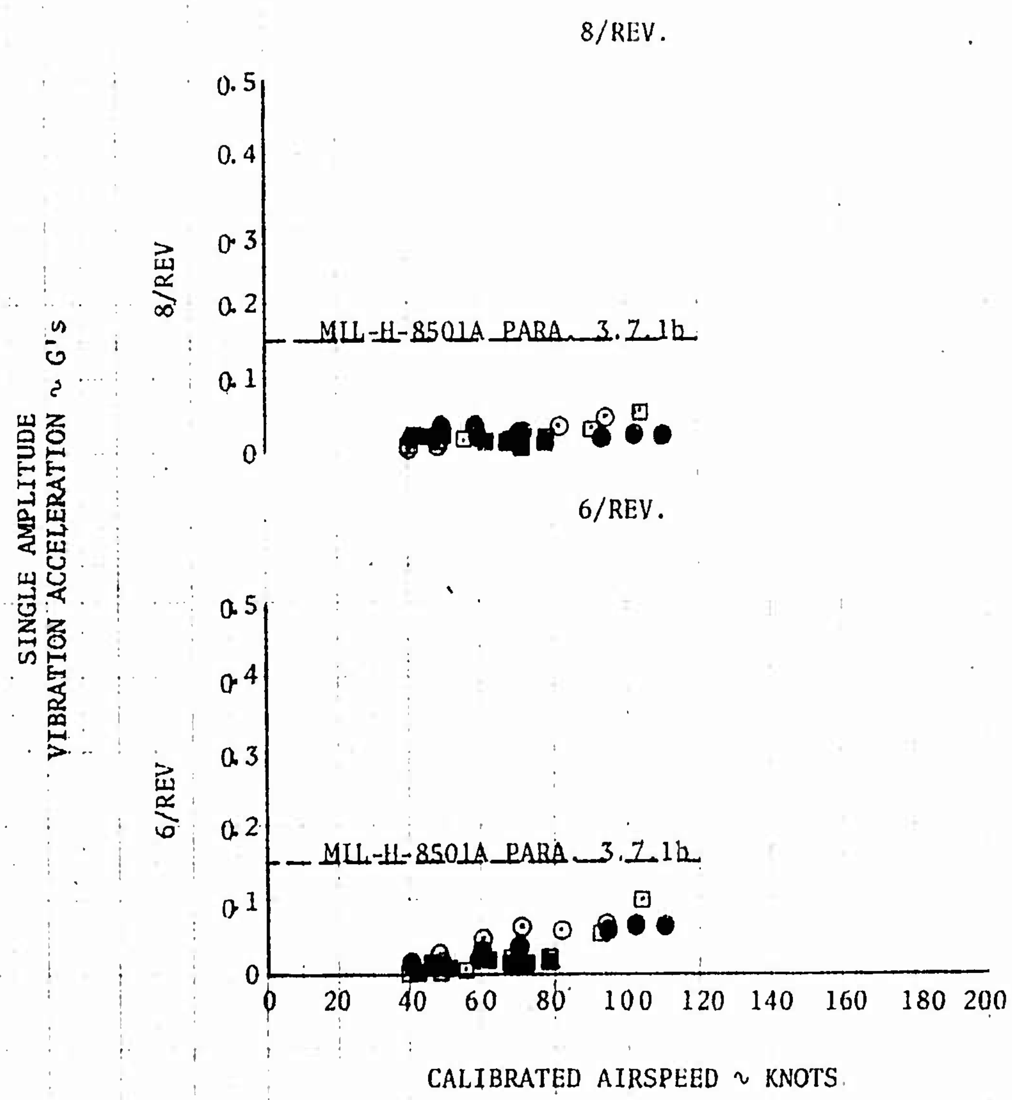


FIGURE NO. 23
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8170 | 4950 | 317.0 | 201.7 (AFT) | CLEAN | AUTO. |
| ● | 8170 | 4950 | 323.0 | 201.7 (AFT) | CLEAN | CLIMB |
| □ | 8220 | 6220 | 320.0 | 201.0 (AFT) | HVY HOG | AUTO. |
| ■ | 8220 | 6220 | 324.0 | 201.0 (AFT) | HVY HOG | CLIMB |

COPILOT LATERAL

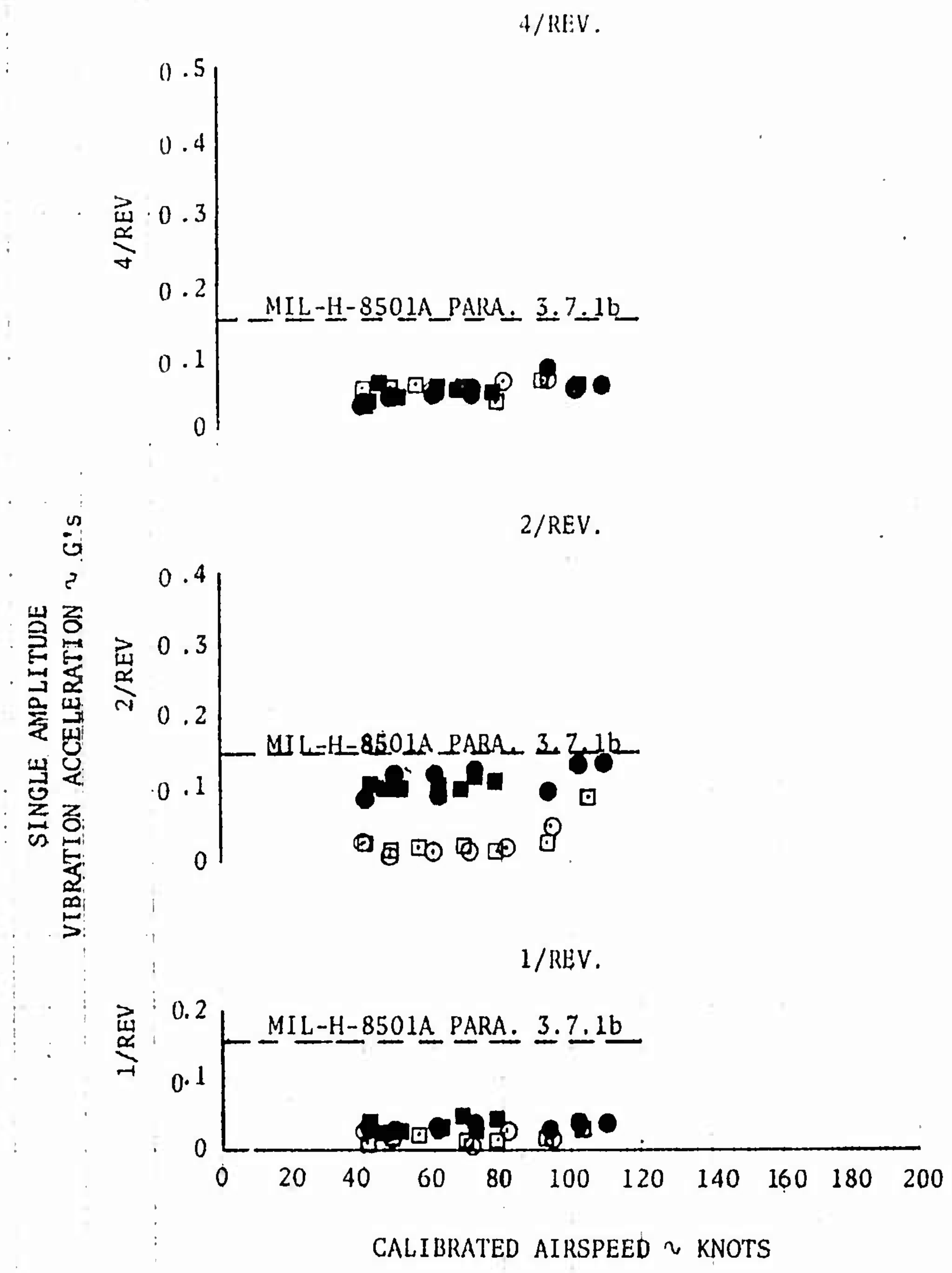


FIGURE NO. 23 CONTINUED

COPILOT LATERAL

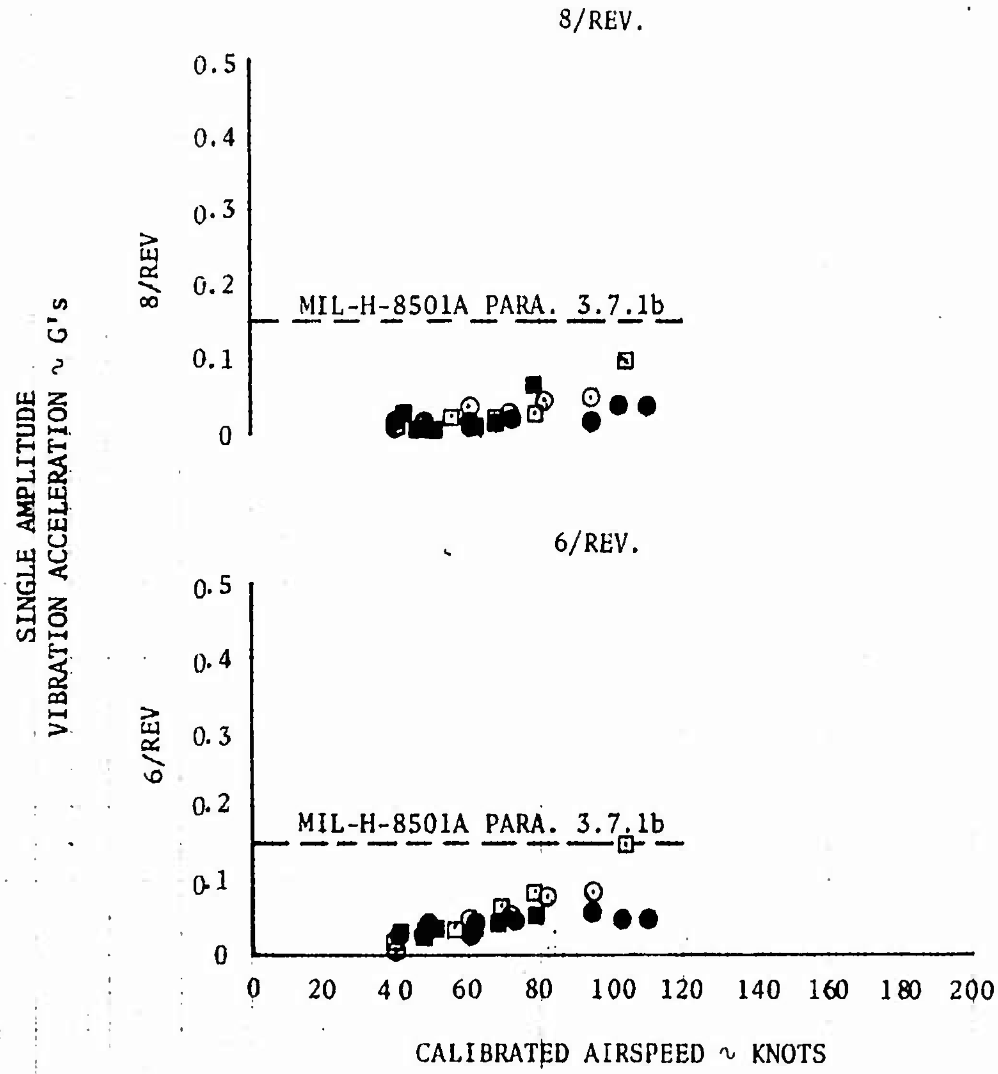


FIGURE NO. 24
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8170 | 4950 | 317.0 | 201.7 (AFT) | CLEAN | AUTO. |
| ● | 8170 | 4950 | 323.0 | 201.7 (AFT) | CLEAN | CLIMB |
| □ | 8220 | 6220 | 320.0 | 201.0 (AFT) | HVY HOG | AUTO. |
| ■ | 8220 | 6220 | 324.0 | 201.0 (AFT) | HVY HOG | CLIMB |

SITE MOUNTING LATERAL

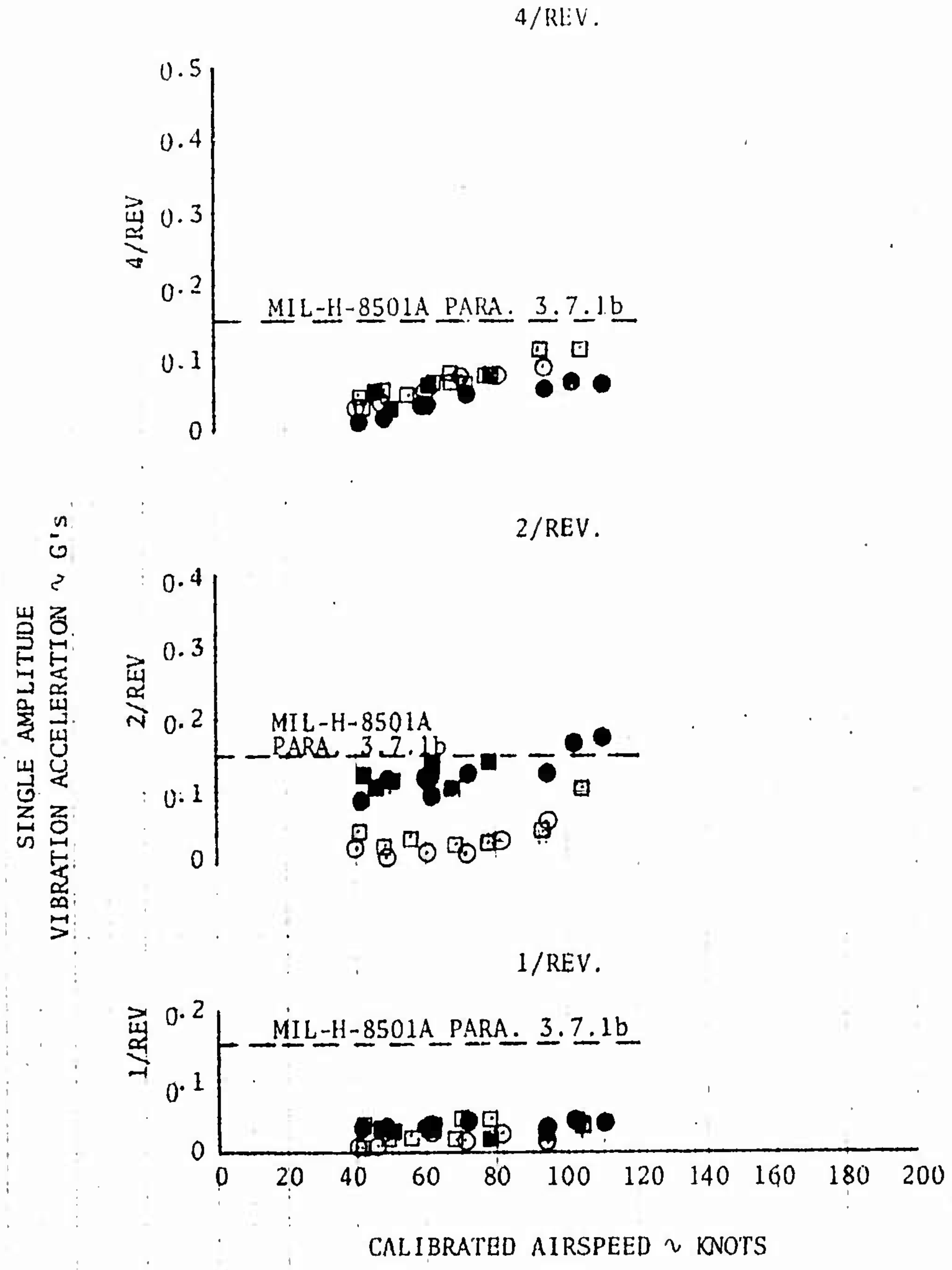


FIGURE NO. 24 CONTINUED

SITE MOUNTING LATERAL

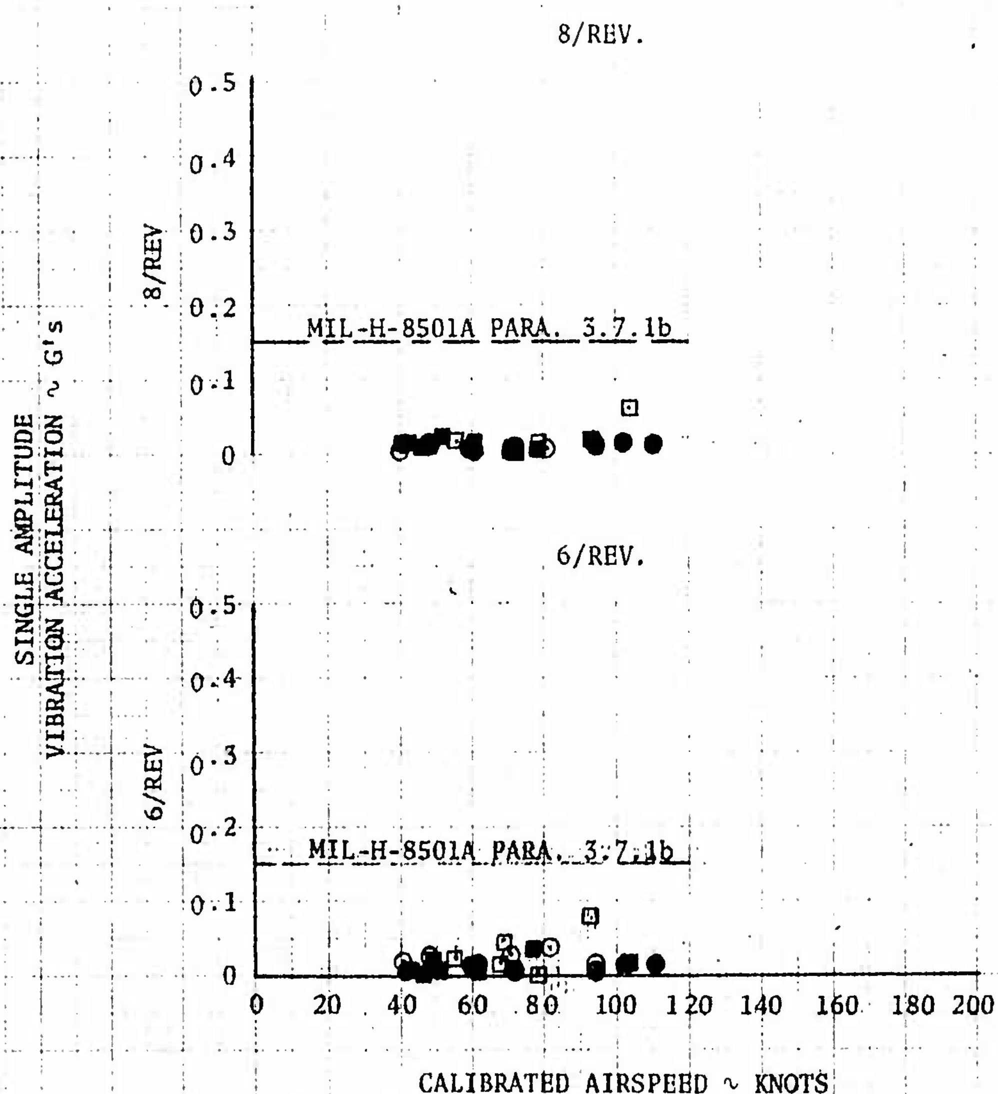


FIGURE NO. 25
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 7355 | 4460 | 323.5 | 190.2 (FWD) | CLEAN | LEVEL FLT. |
| ■ | 7205 | 5520 | 321.0 | 189.9 (FWD) | CLEAN | DIVE |

PILOT VERTICAL

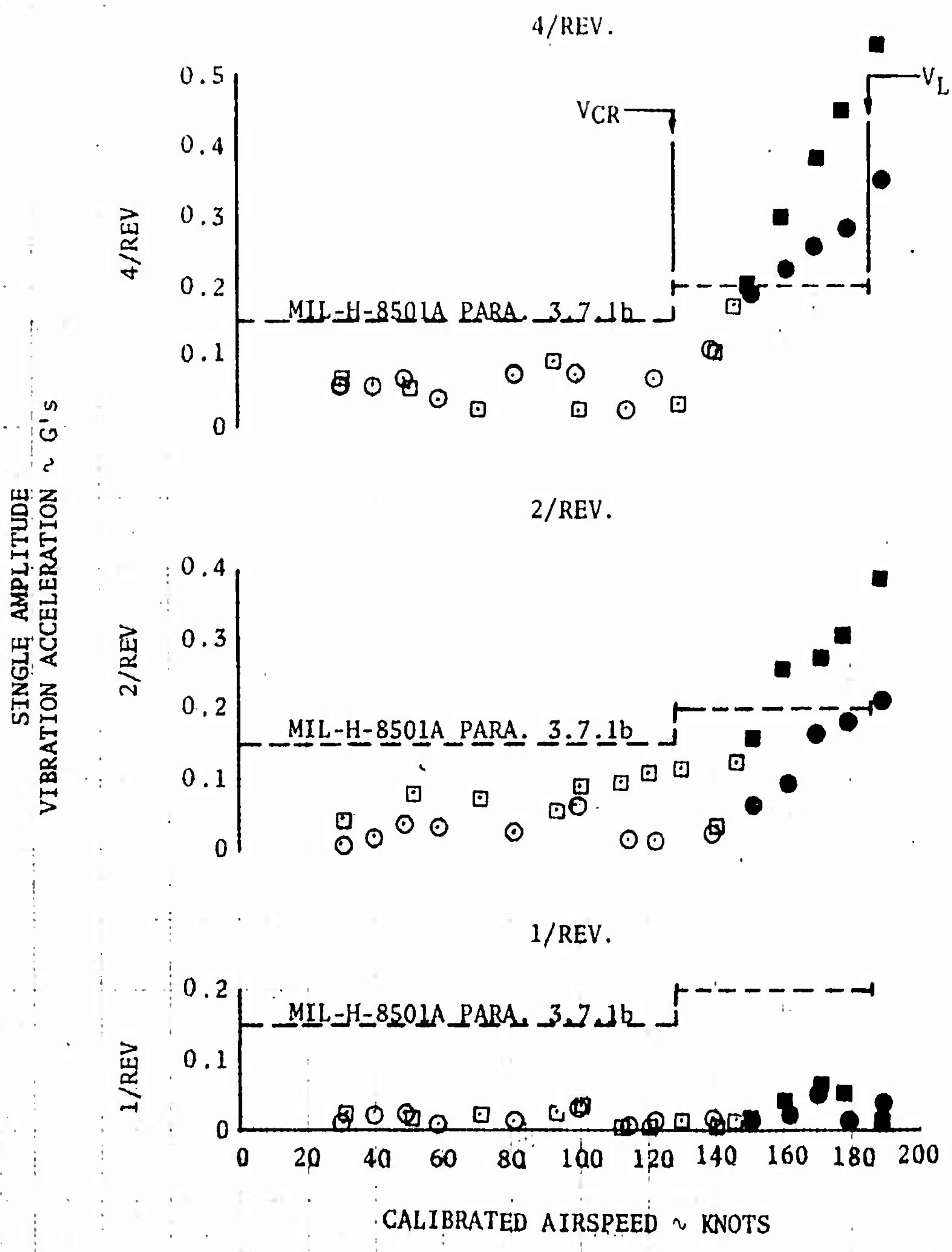


FIGURE NO. 25 CONTINUED

PILOT VERTICAL

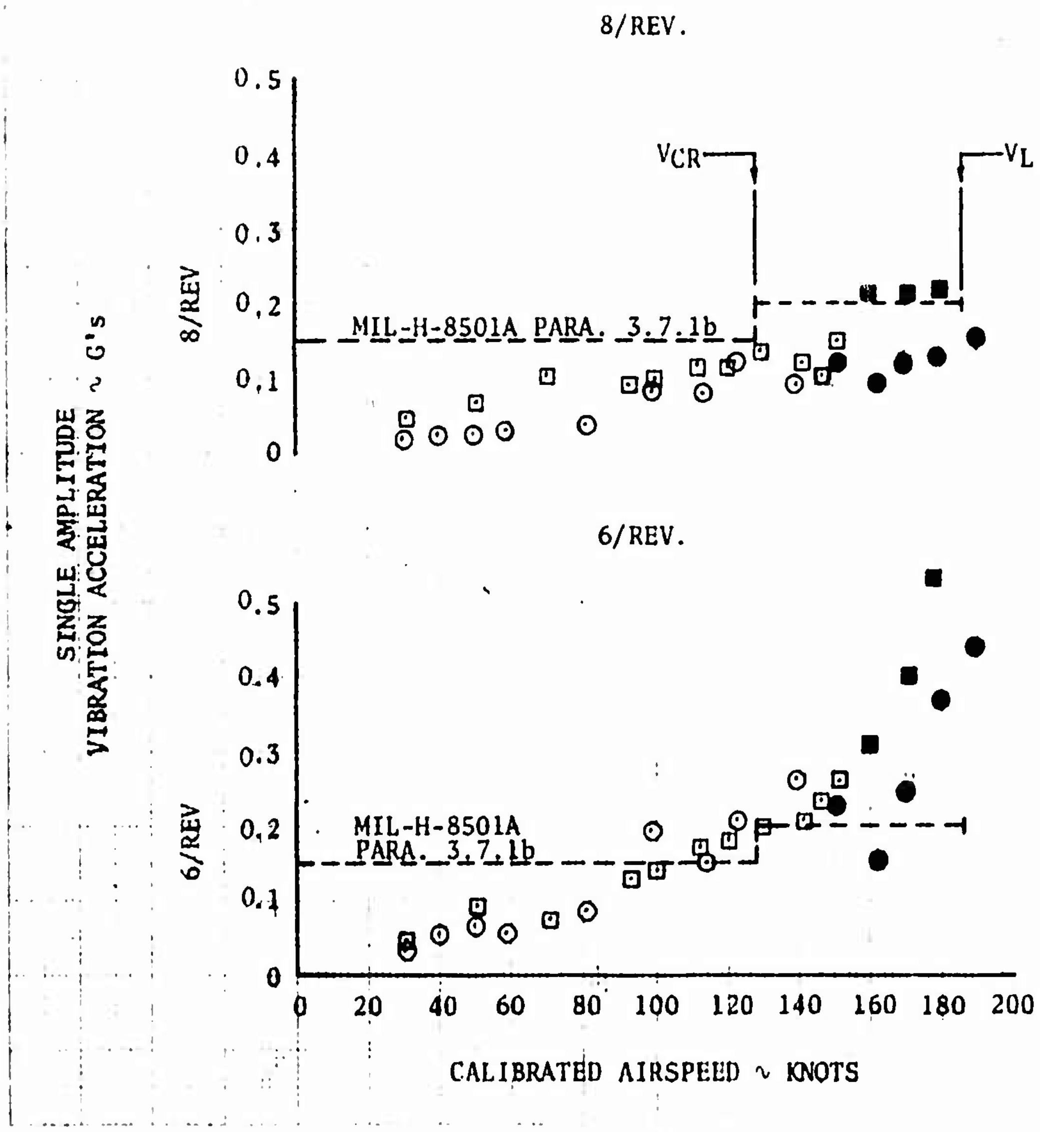


FIGURE NO. 26
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 7355 | 4460 | 323.5 | 190.2 (FWD) | CLEAN | LEVEL FLT. |
| ■ | 7205 | 5520 | 321.0 | 189.9 (FWD) | CLEAN | DIVE |

COPILOT VERTICAL

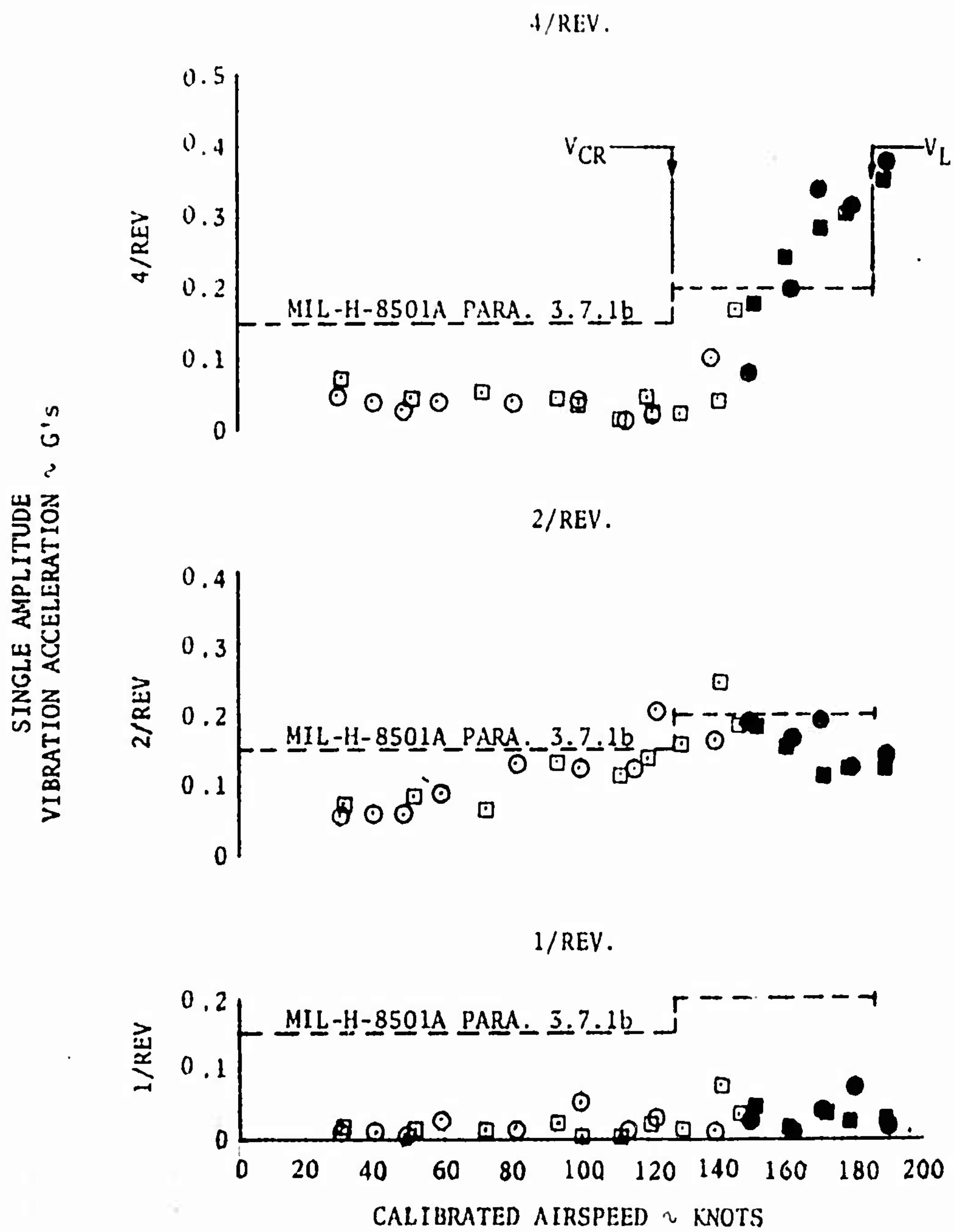


FIGURE NO. [illegible] CONTINUED

COPILOT VERTICAL

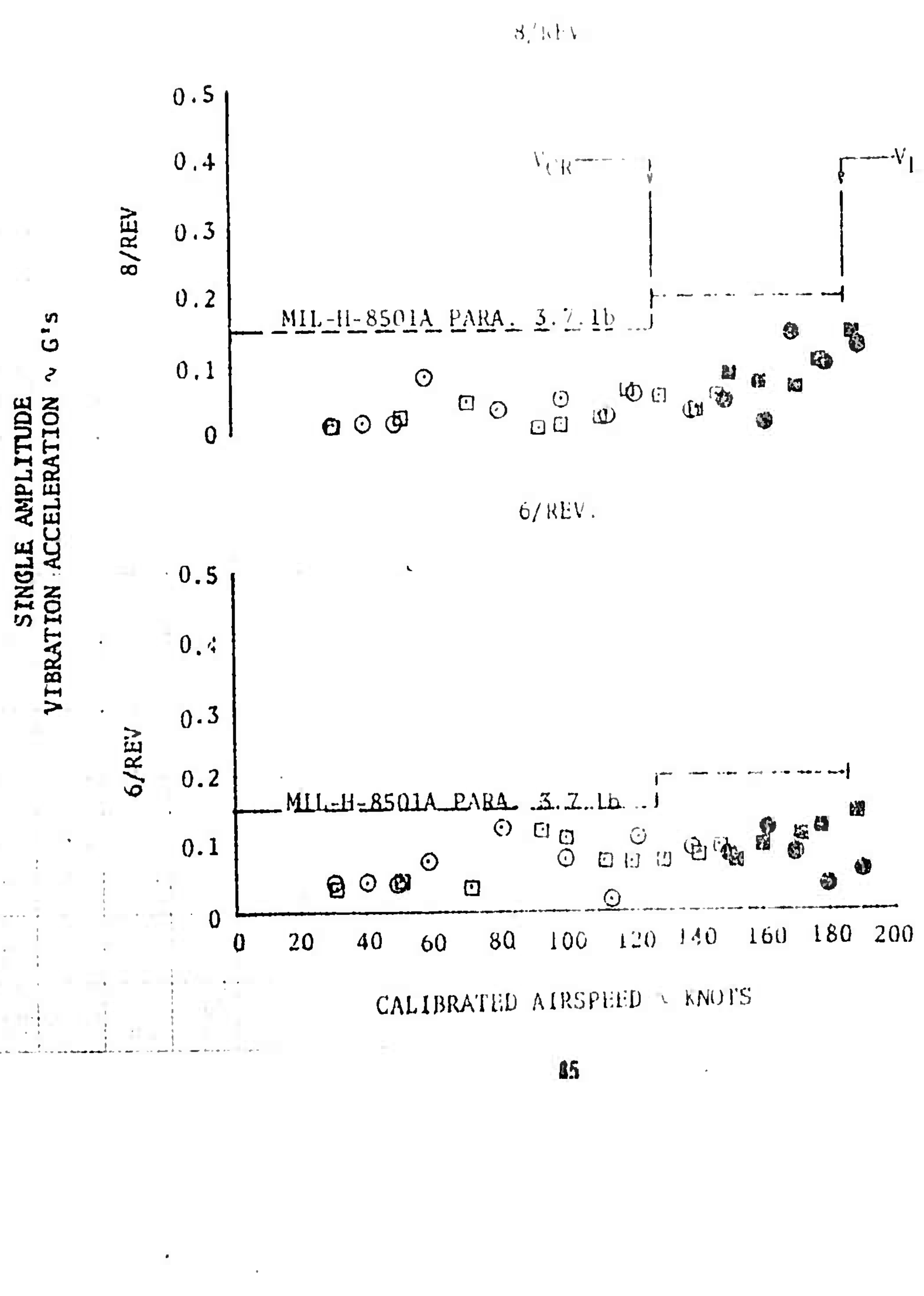


FIGURE NO 27

VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 7355 | 4460 | 323.5 | 190.2 (FWD) | CLEAN | LEVEL FLT. |
| ■ | 7205 | 5520 | 321.0 | 189.9 (FWD) | CLEAN | DIVE |

SITE MOUNTING VERTICAL

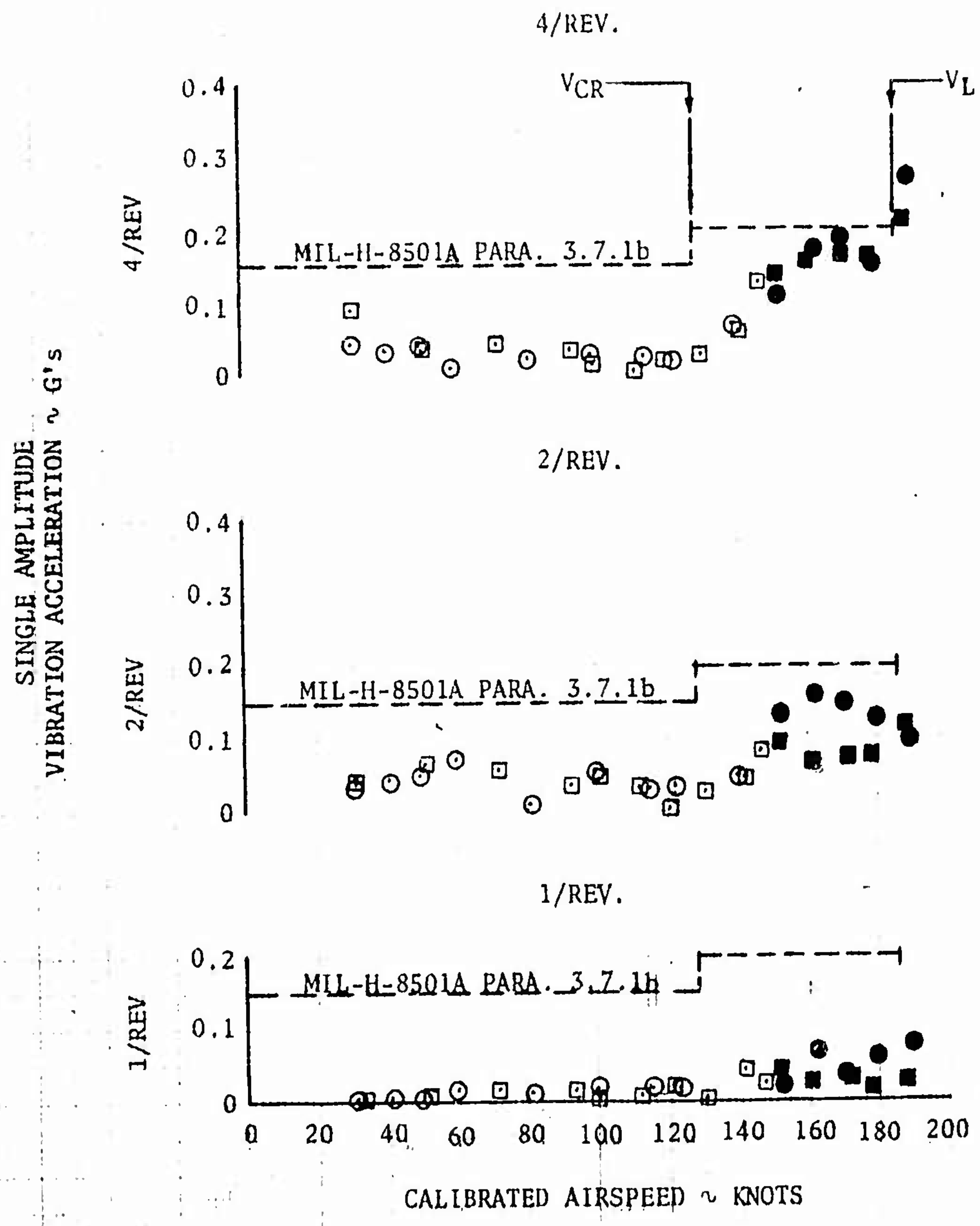


FIGURE NO. 27 CONTINUED

SITE MOUNTING VERTICAL

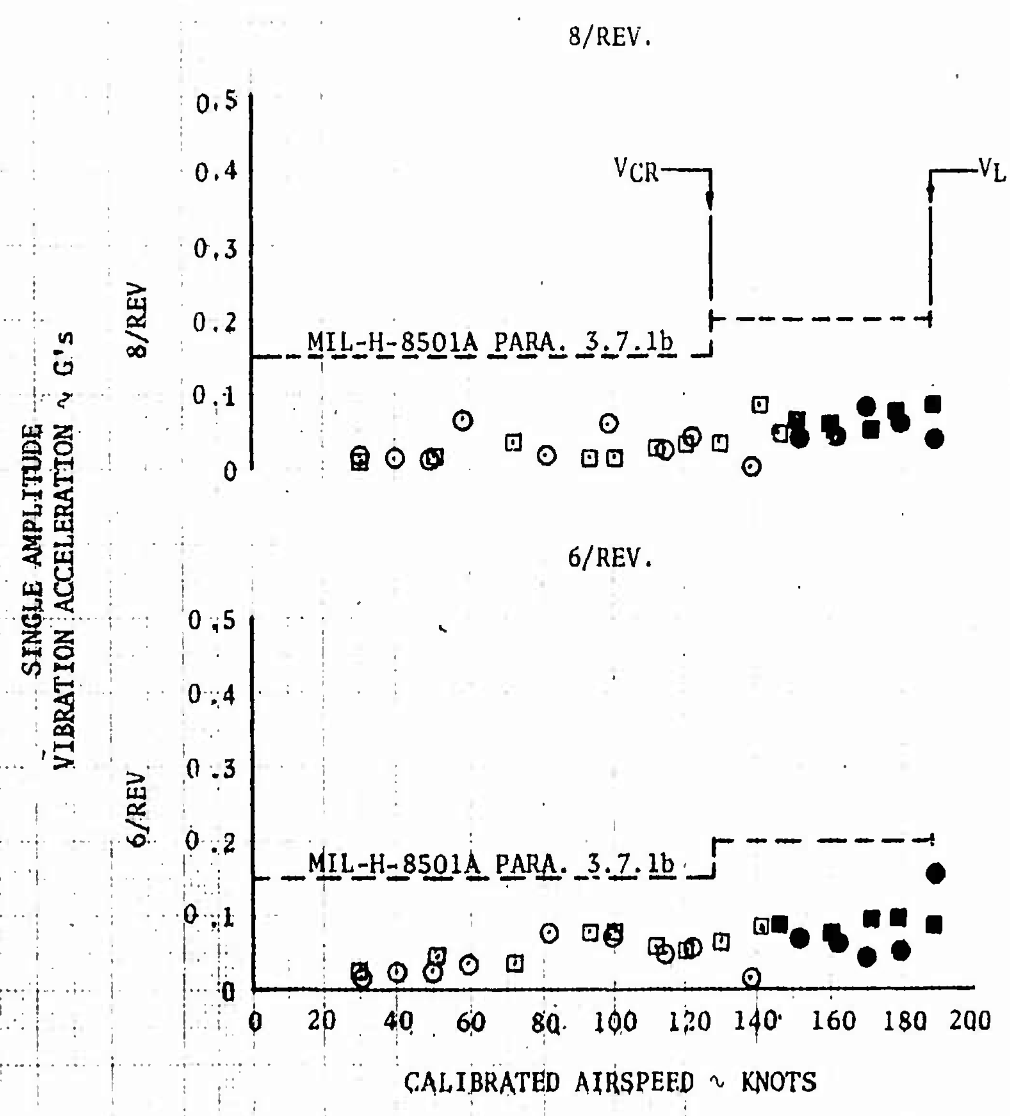


FIGURE NO. 28
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 7355 | 4460 | 323.5 | 190.2 (FWD) | CLEAN | LEVEL FLT. |
| ■ | 7205 | 5520 | 321.0 | 189.9 (FWD) | CLEAN | DIVE |

PILOT LATERAL

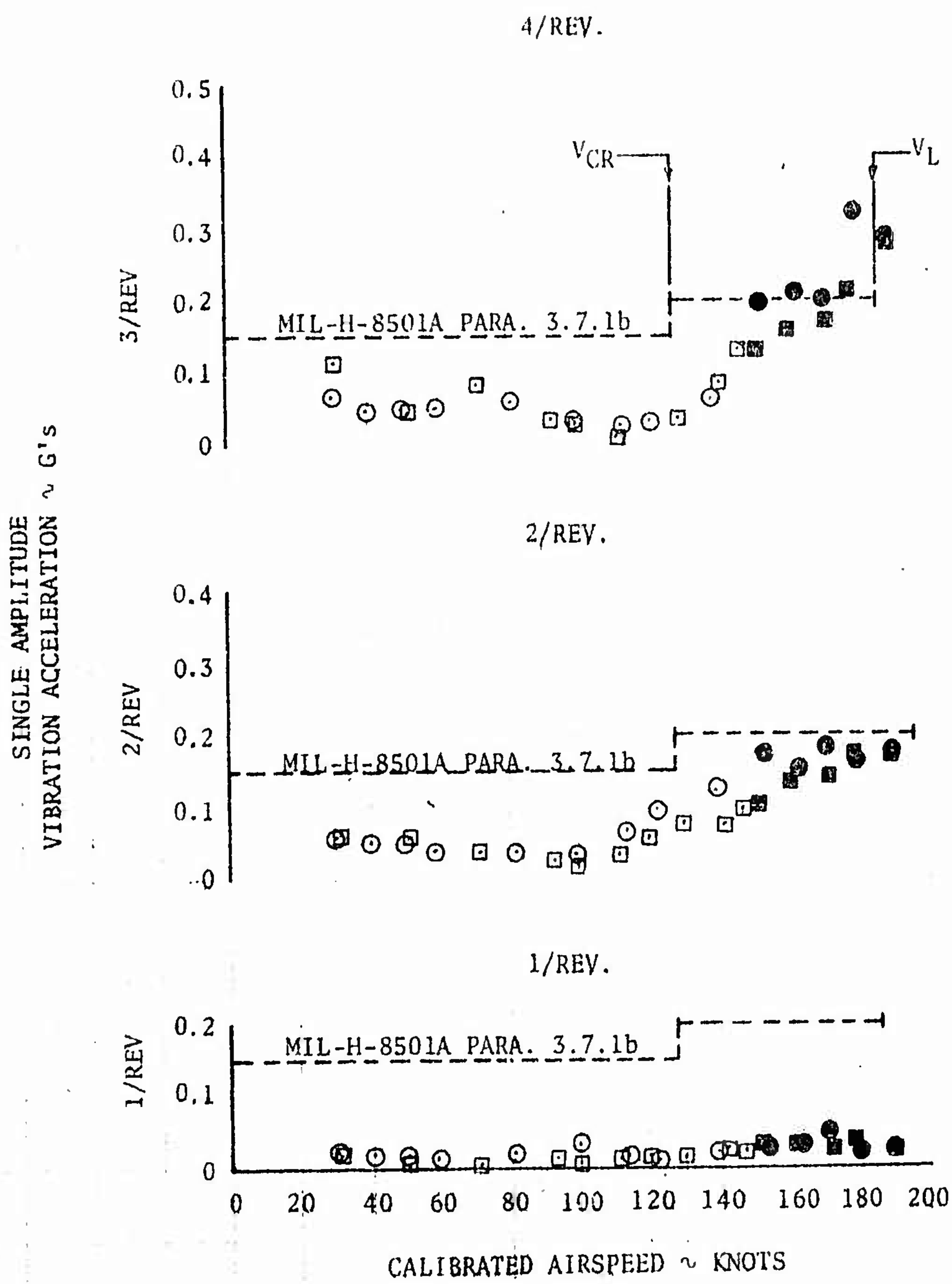


FIGURE NO. 28 CONTINUED

PILOT LATERAL

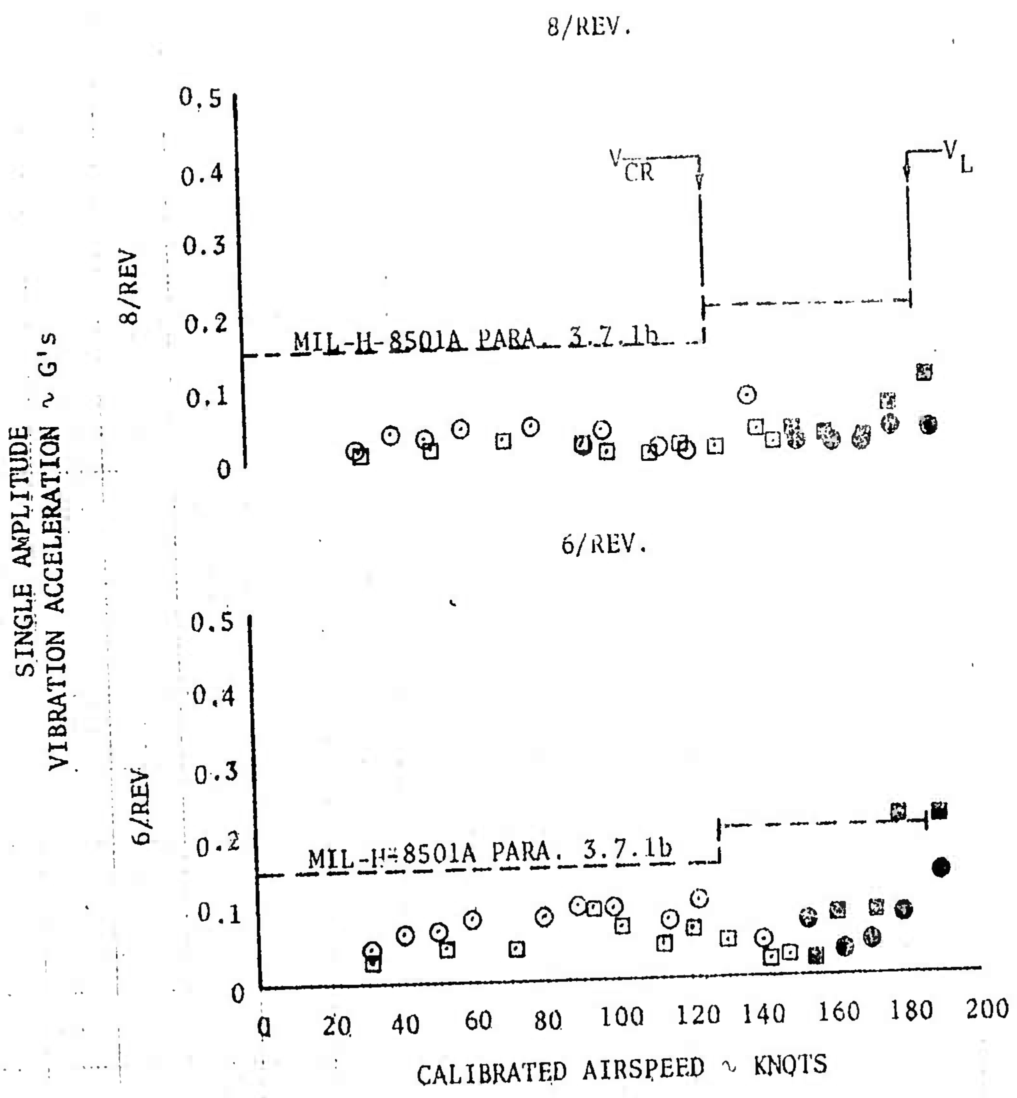


FIGURE NO. 29
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 7355 | 4460 | 323.5 | 190.2 (FWD) | CLEAN | LEVEL FLT. |
| ■ | 7205 | 5520 | 321.0 | 189.9 (FWD) | CLEAN | DIVE |

COPILOT LATERAL

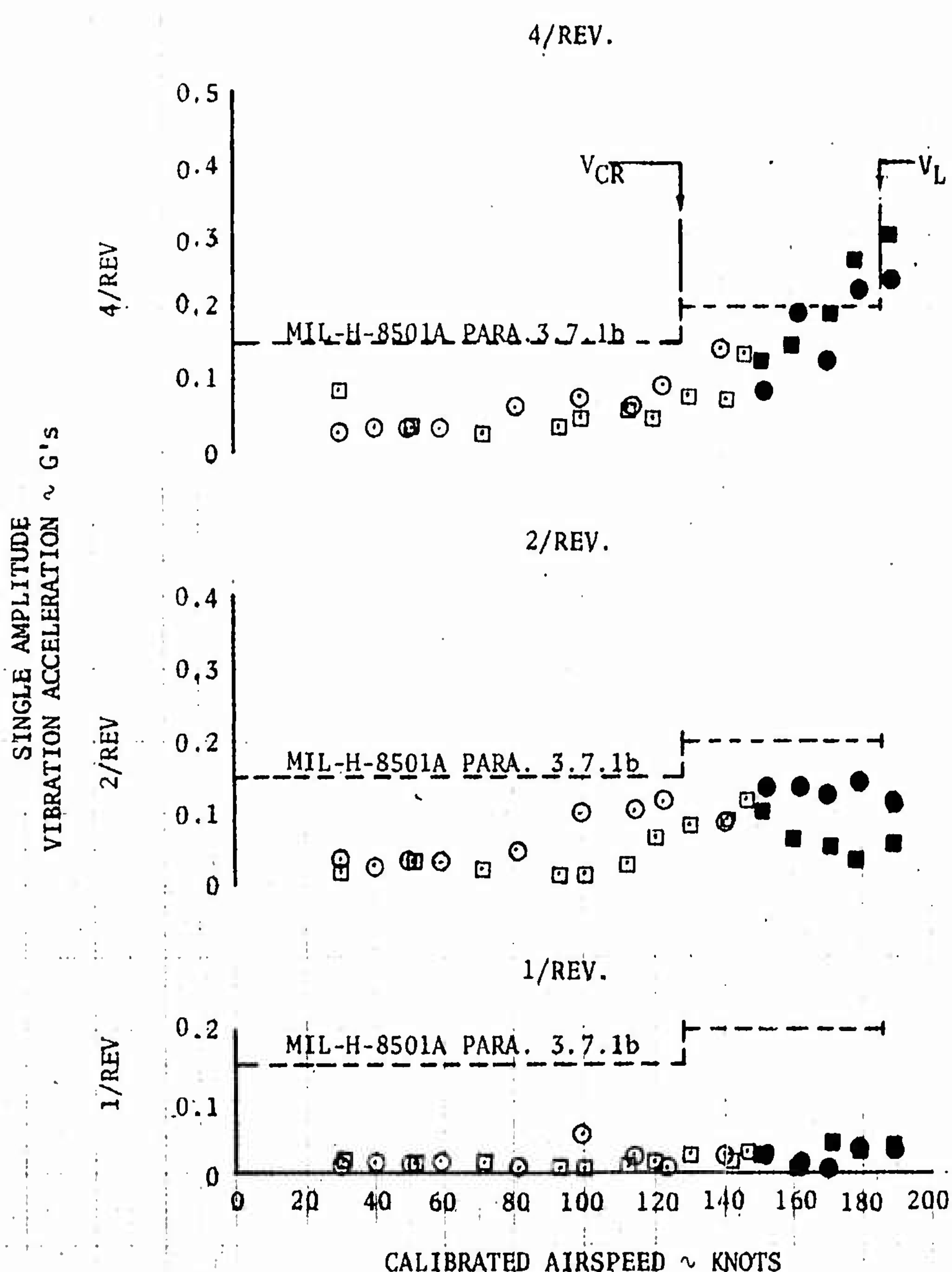


FIGURE NO. 29 CONTINUED

COPILOT LATERAL

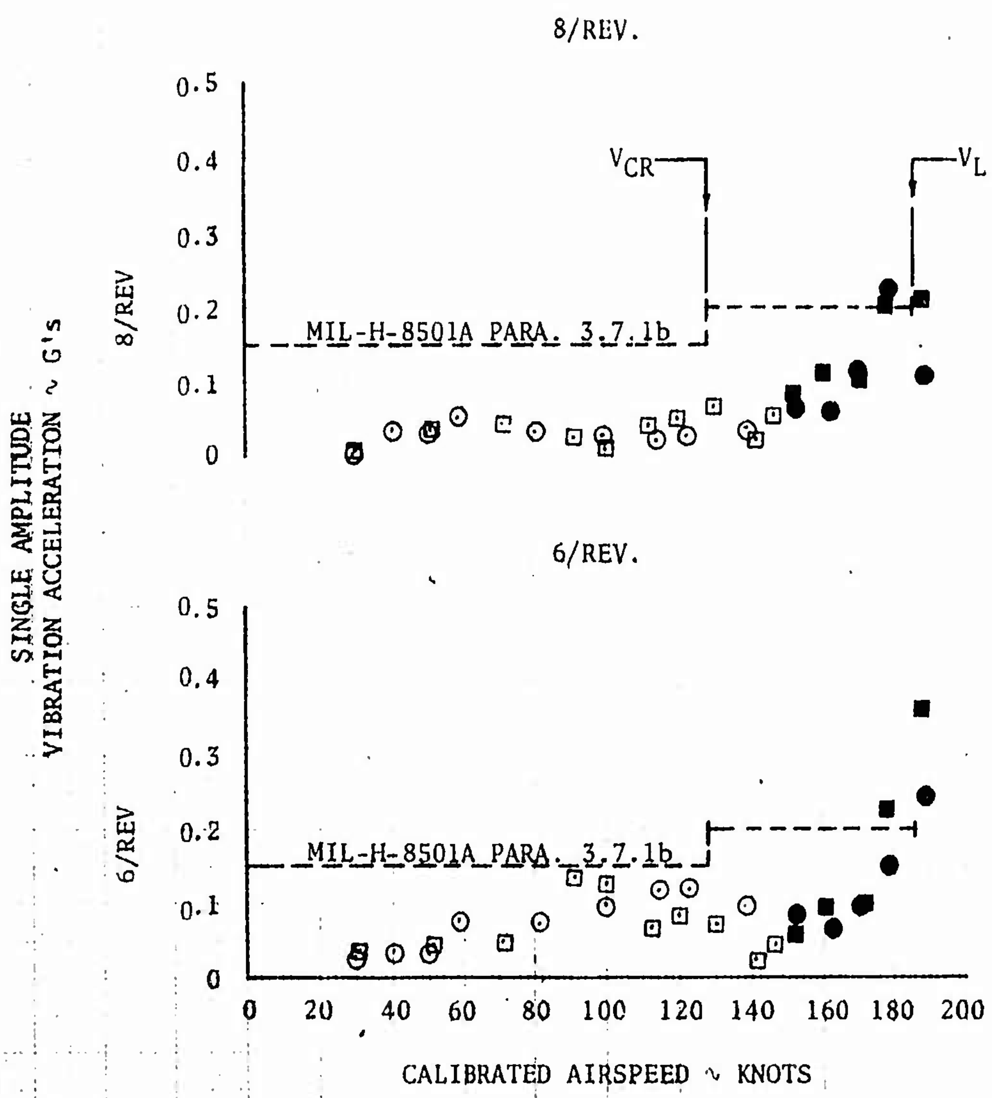
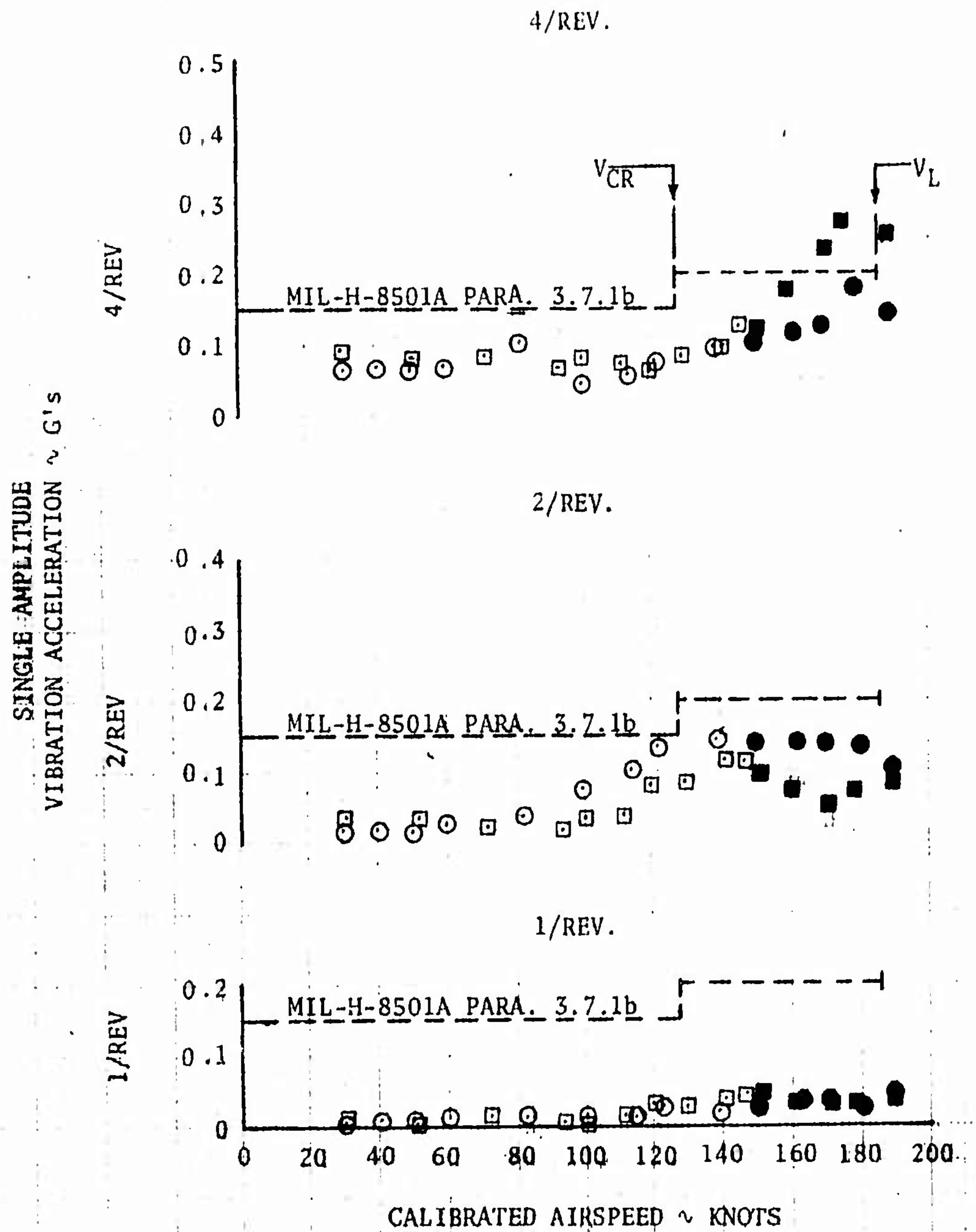


FIGURE NO. 30
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8470 | 4980 | 323.5 | 191.4 (FWD) | CLEAN | LEVEL FLT. |
| ● | 8240 | 5440 | 324.0 | 191.2 (FWD) | CLEAN | DIVE |
| □ | 7355 | 4460 | 323.5 | 190.2 (FWD) | CLEAN | LEVEL FLT. |
| ■ | 7205 | 5520 | 321.0 | 189.9 (FWD) | CLEAN | DIVE |

SITE MOUNTING LATERAL



SITE MOUNTING LATERAL

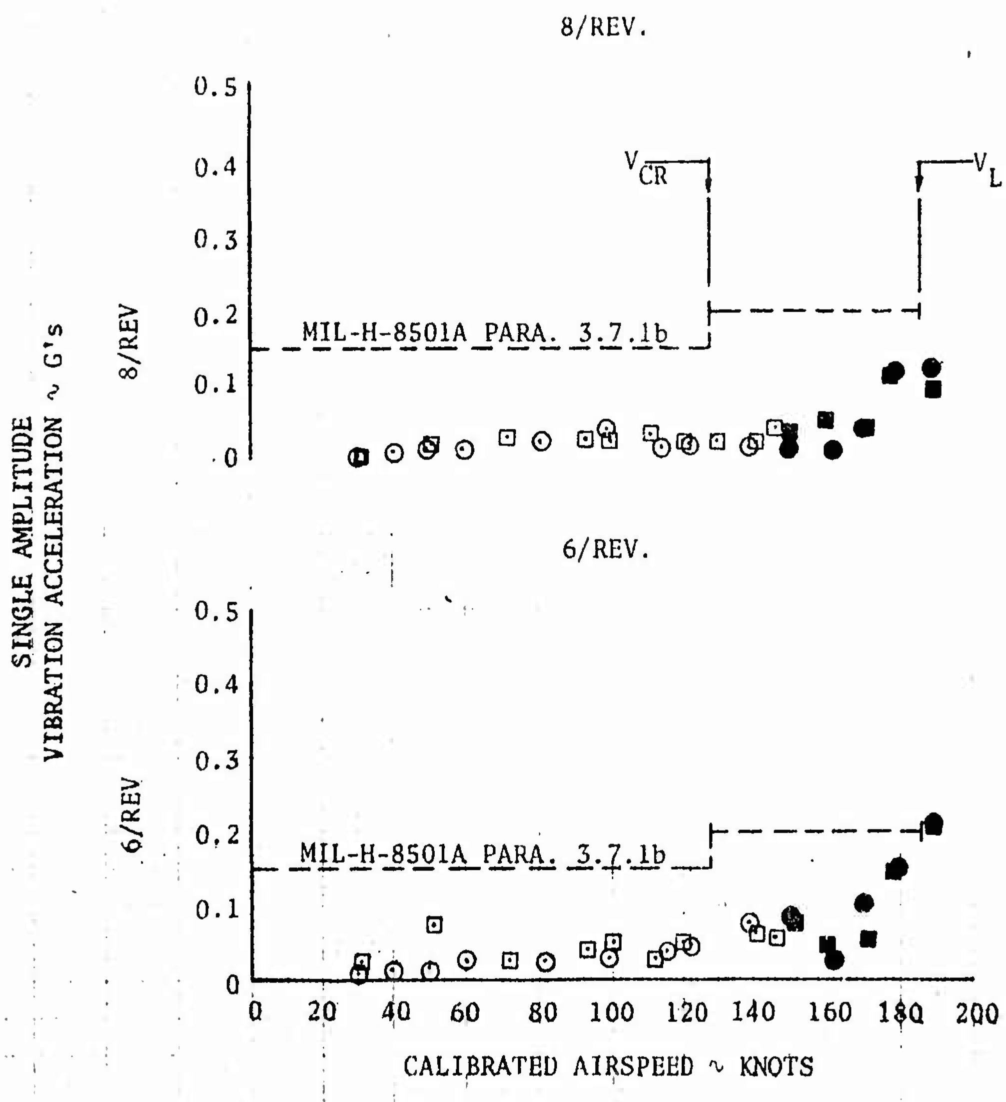


FIGURE NO. 31
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 9435 | 3295 | 323.5 | 200.7 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 9310 | 3270 | 324.0 | 200.6 (AFT) | HVY HOG | DIVE |

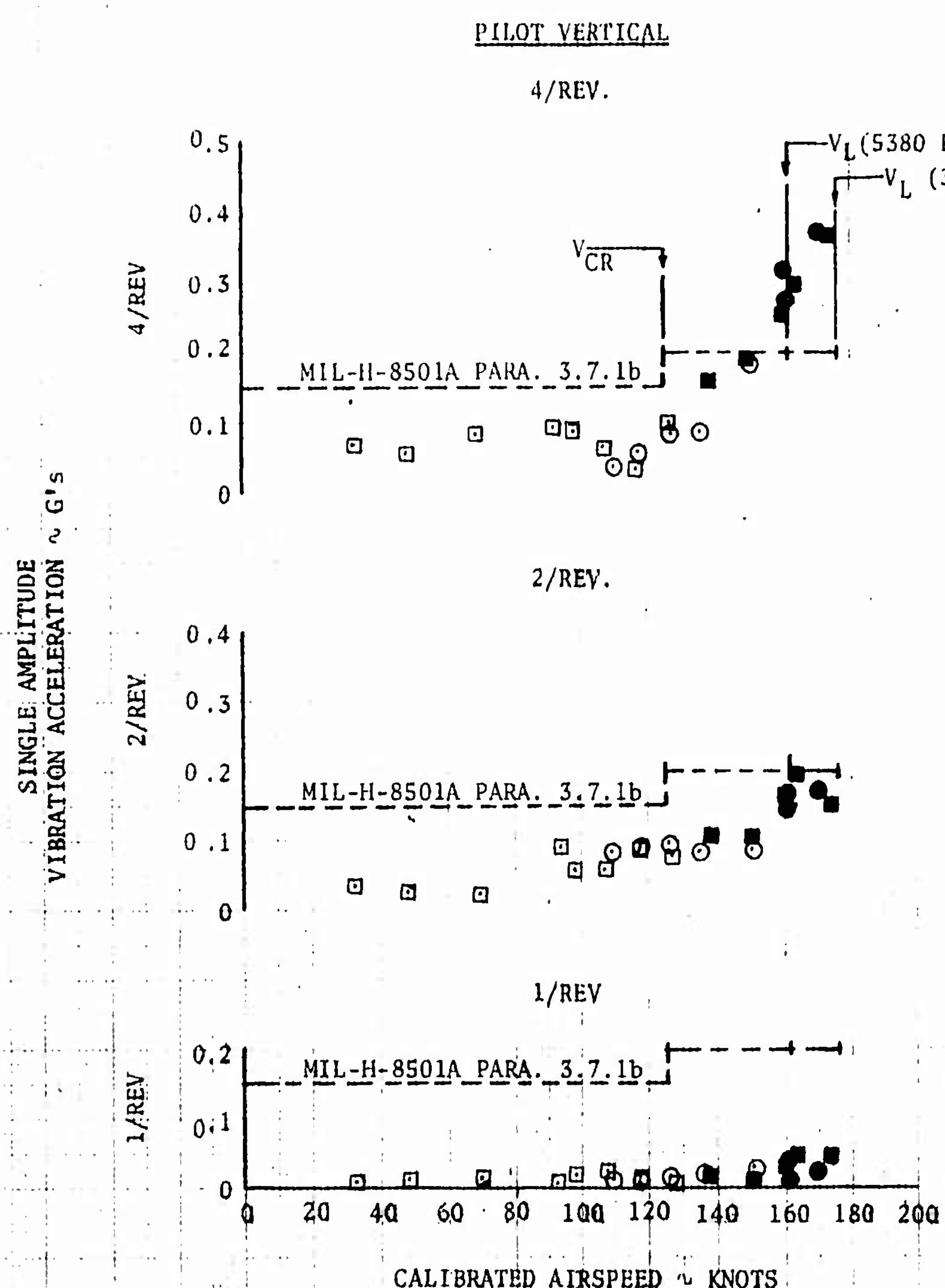


FIGURE NO. 31 CONTINUED

PILOT VERTICAL

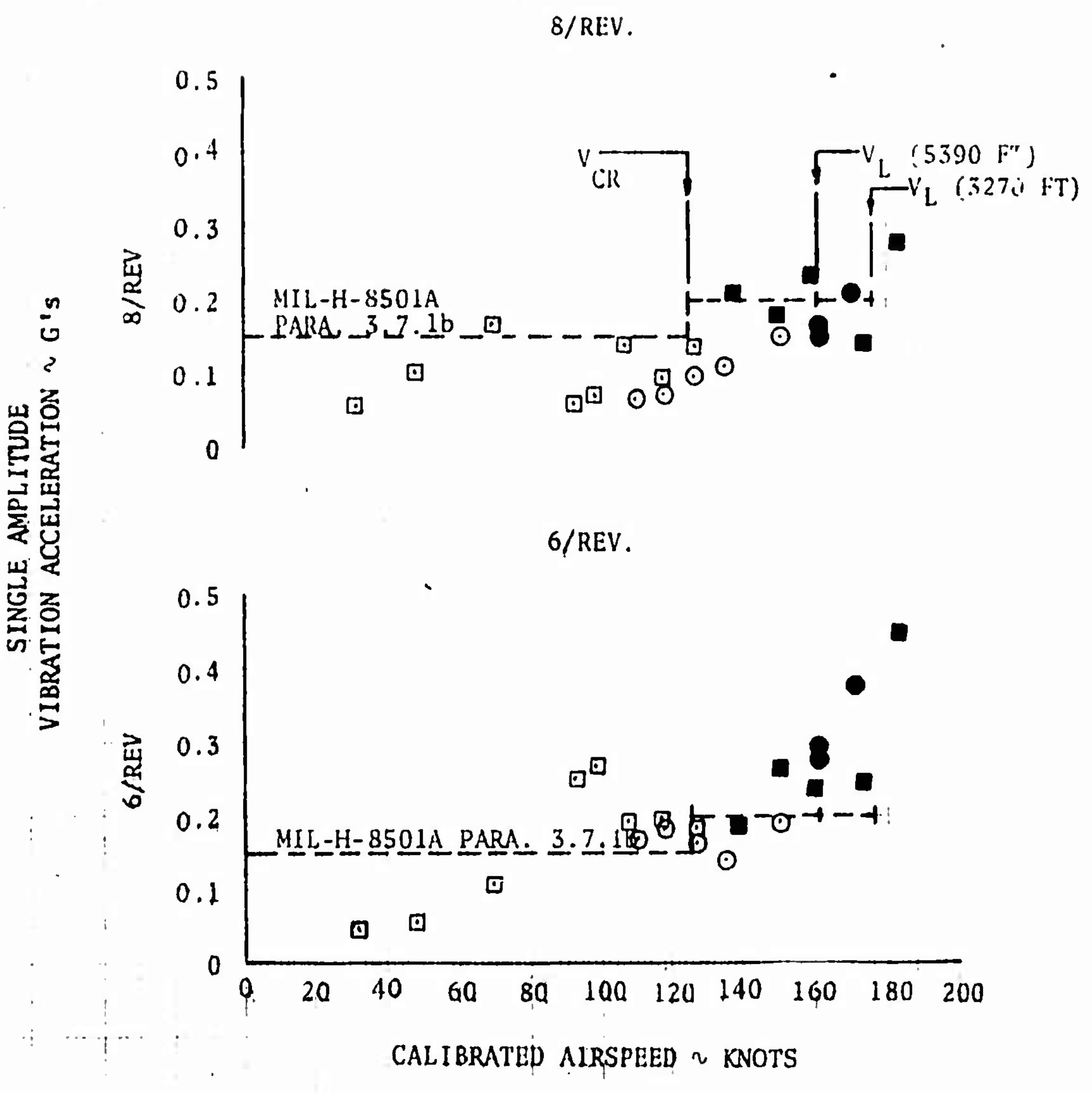


FIGURE NO. 32
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 9435 | 3295 | 323.5 | 200.7 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 9310 | 3270 | 324.0 | 200.6 (AFT) | HVY HOG | DIVE |

COPILOT VERTICAL

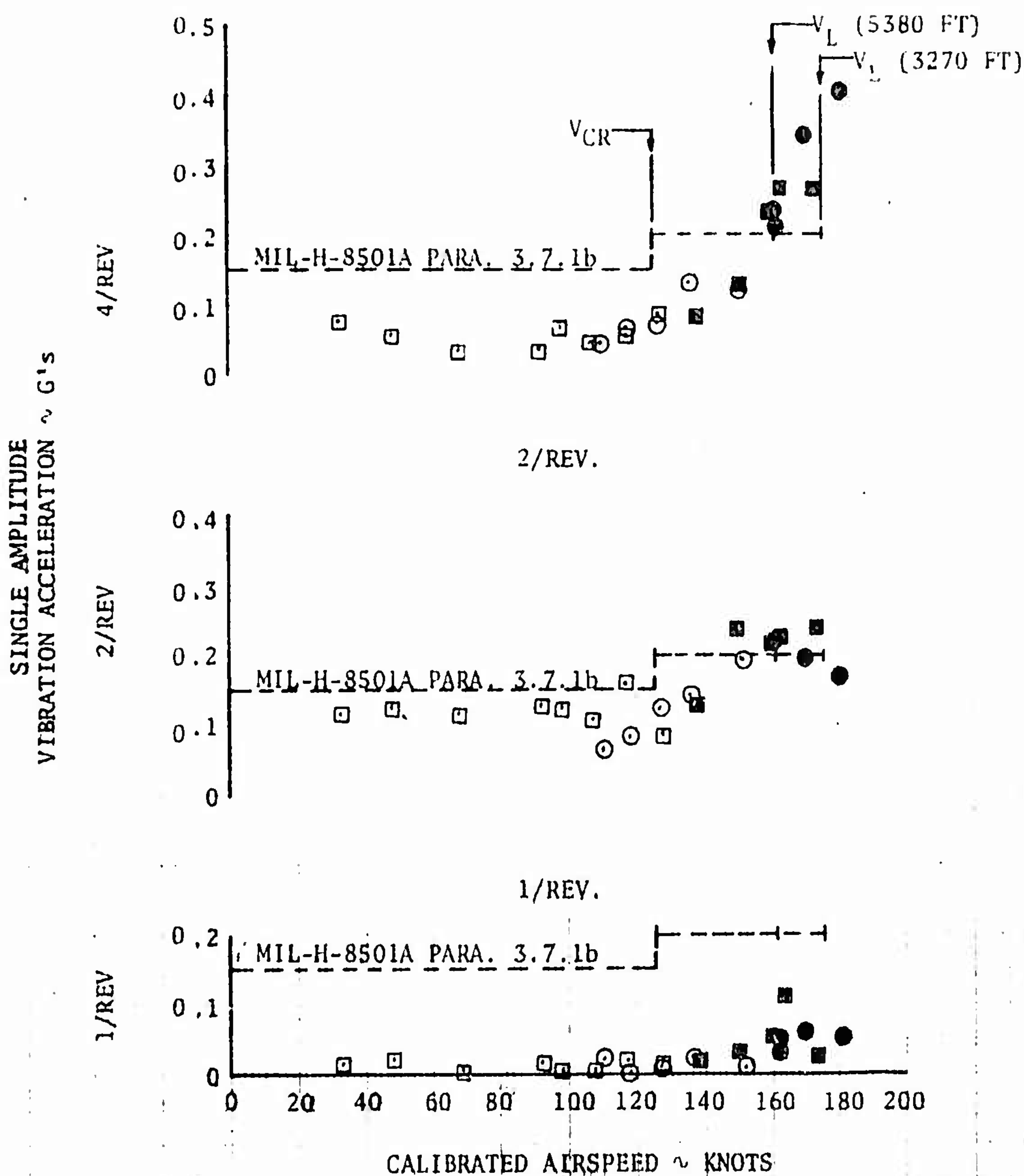


FIGURE NO. 32 CONTINUED

COPILOT VERTICAL

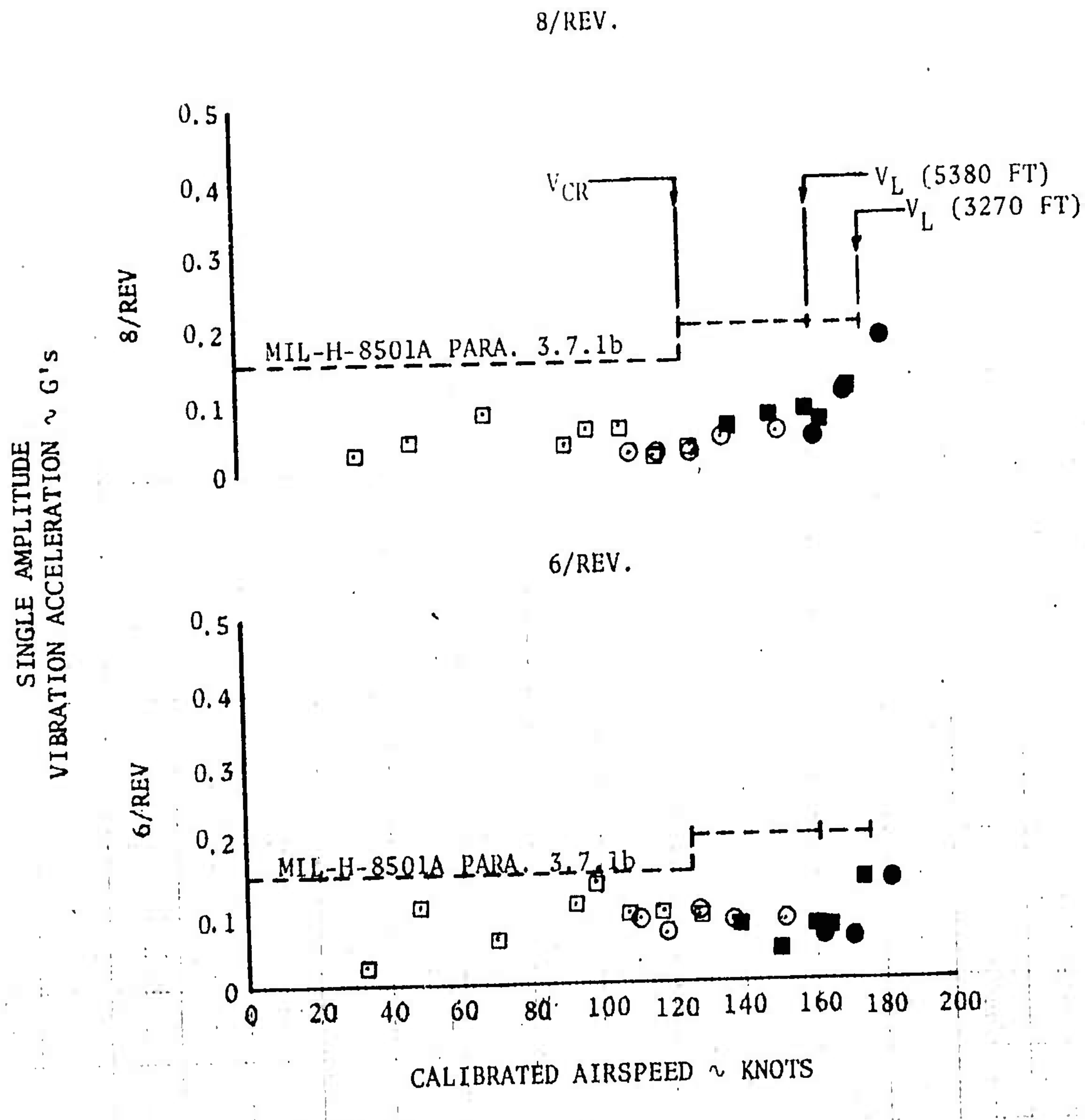


FIGURE NO. 33
VIBRATIONS CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 9435 | 3295 | 323.5 | 200.7 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 9310 | 3270 | 324.0 | 200.6 (AFT) | HVY HOG | DIVE |

SITE MOUNTING VERTICAL

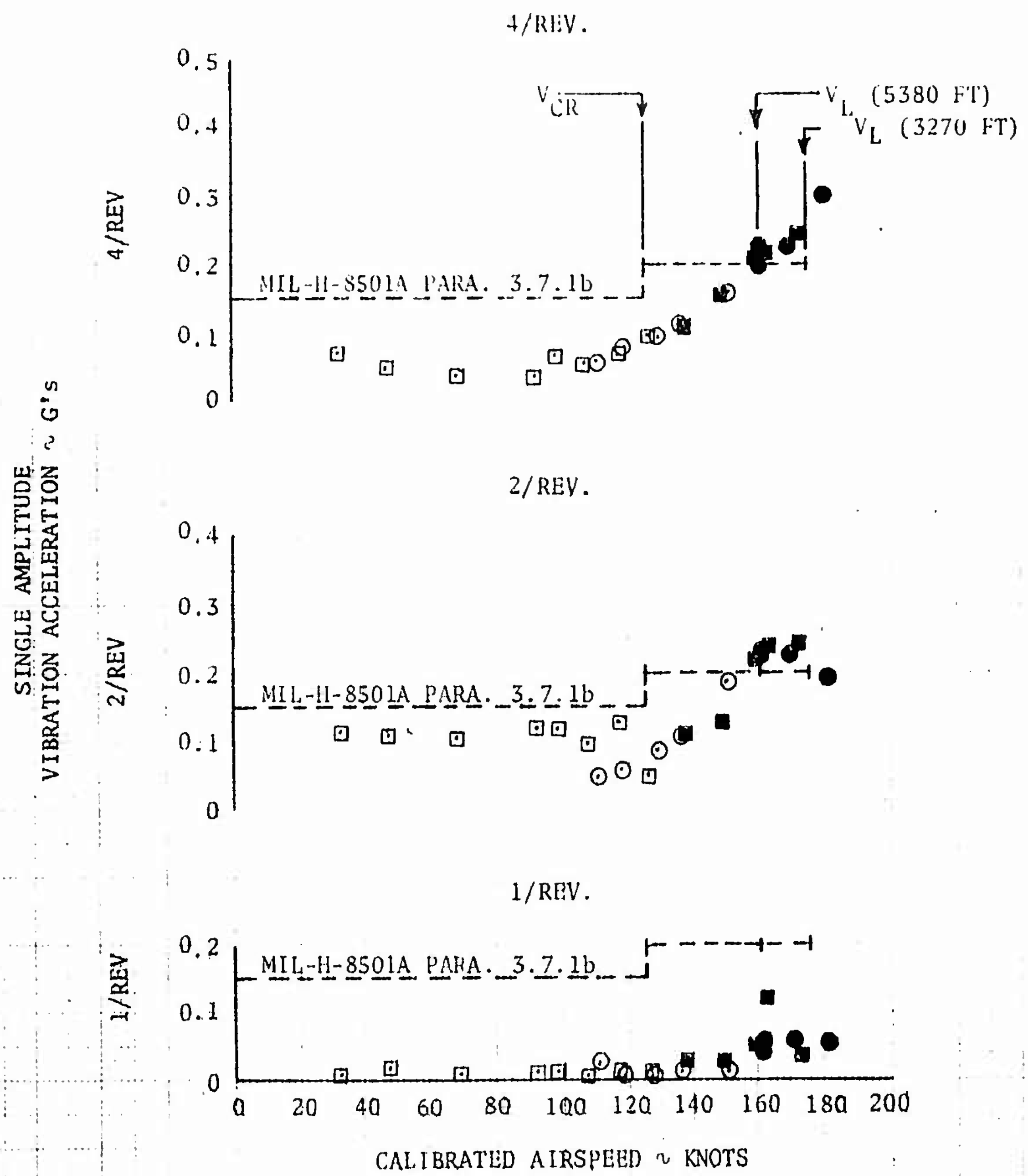


FIGURE NO. 33 CONTINUED

SITE MOUNTING VERTICAL

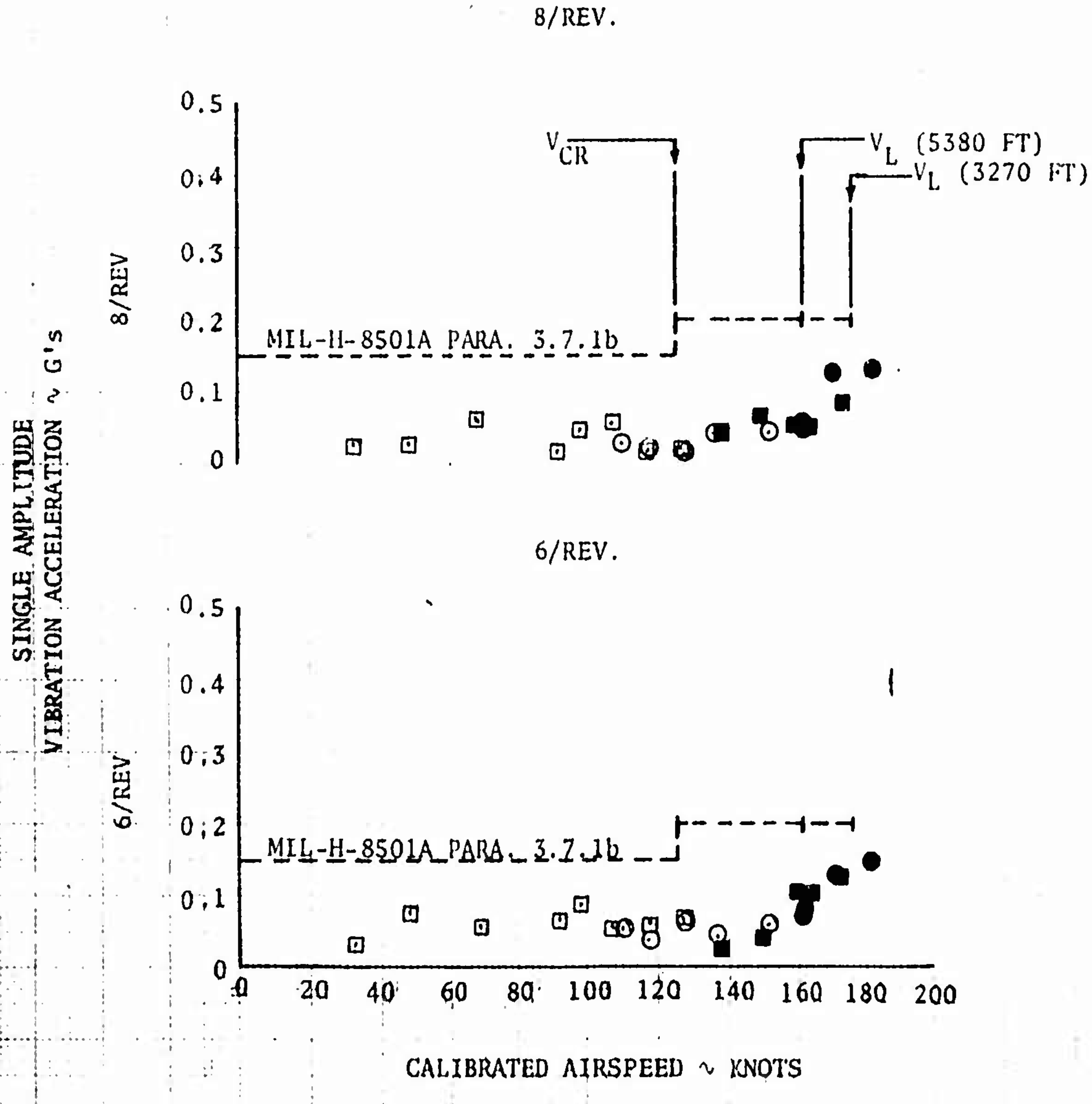


FIGURE NO. 51
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 321.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 9435 | 3295 | 323.5 | 200.7 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 9310 | 3270 | 324.0 | 200.6 (AFT) | HVY HOG | DIVE |

PILOT LATERAL

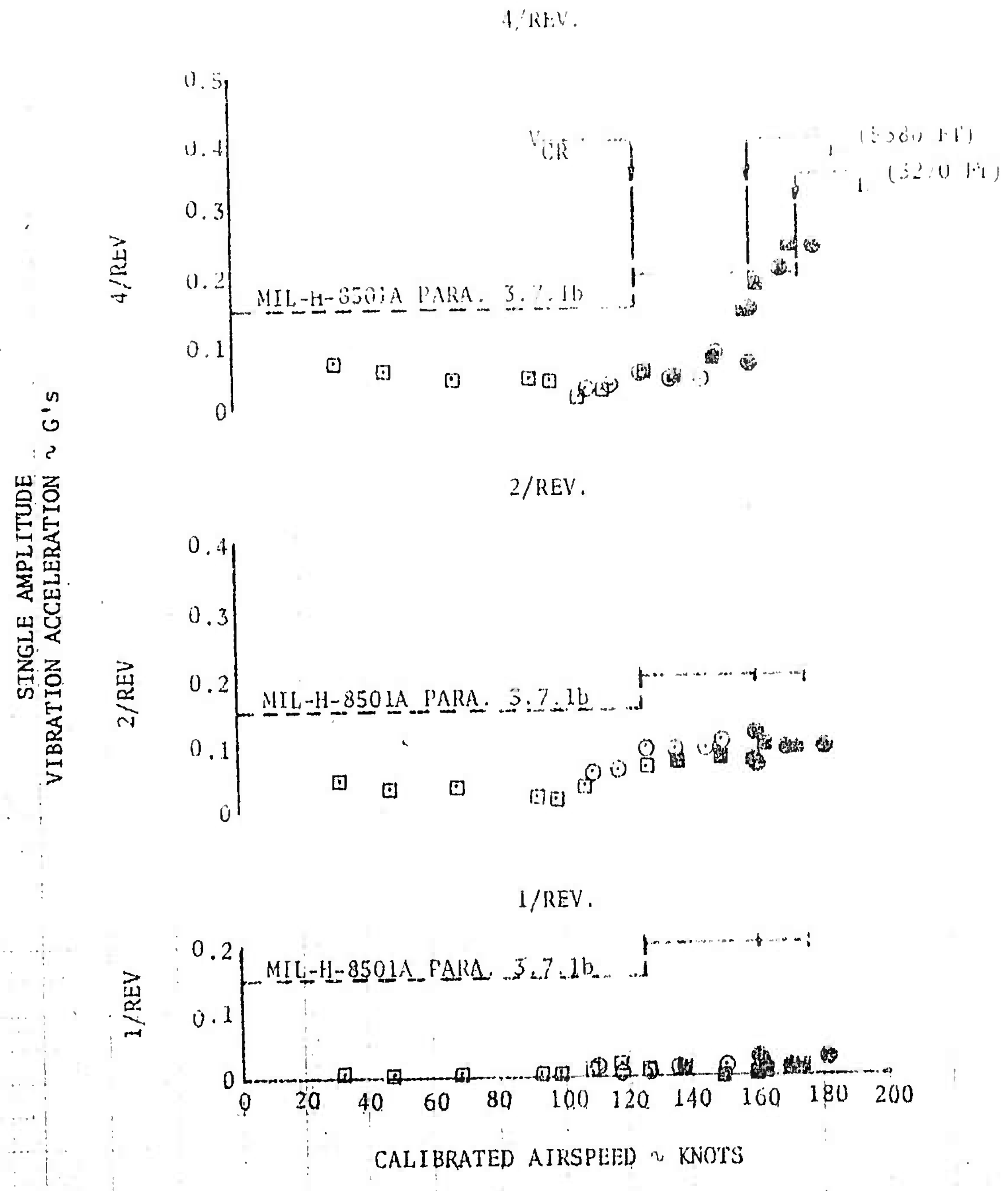


FIGURE NO. 34 CONTINUED

PILOT LATERAL

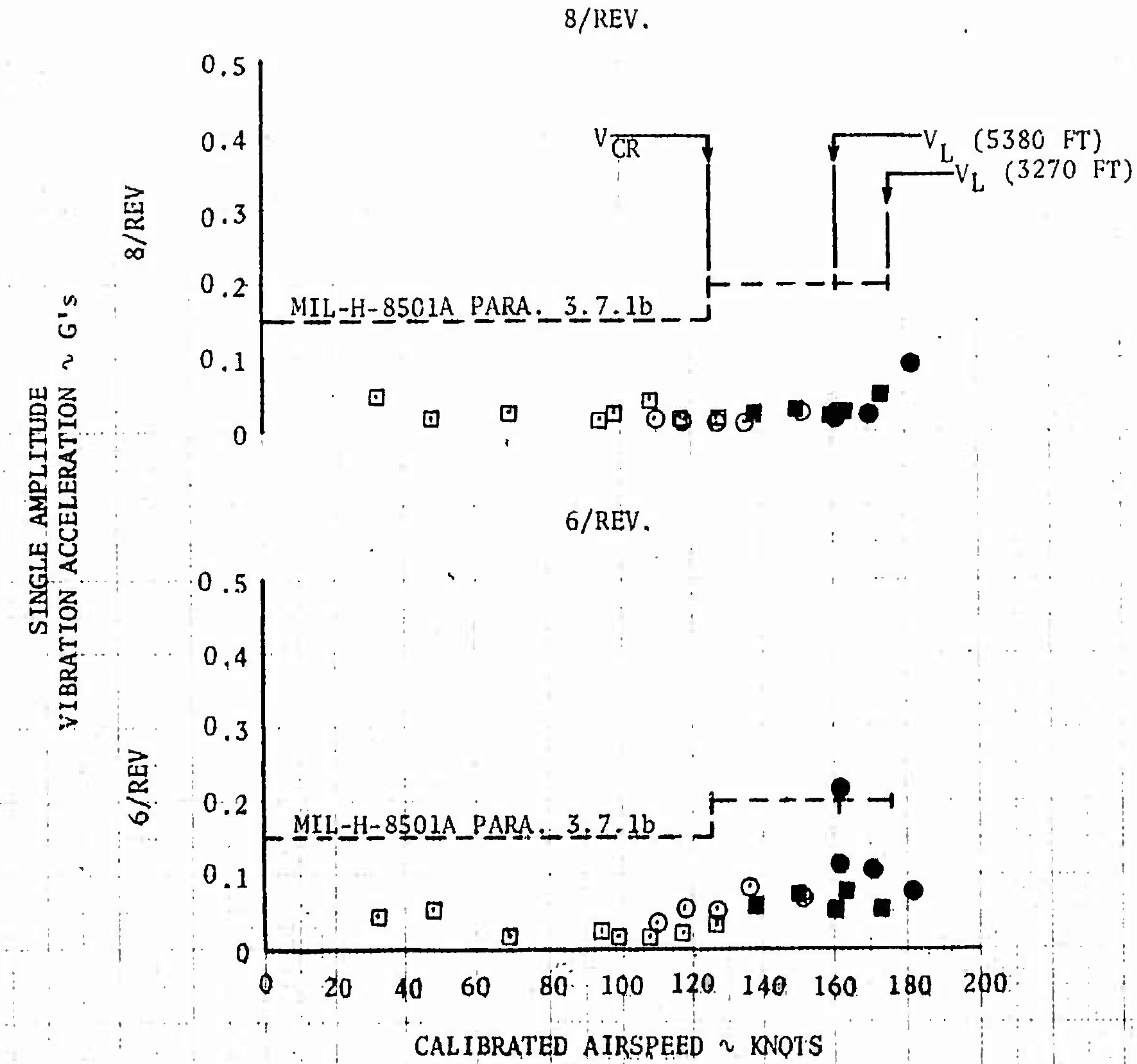


FIGURE NO. 35
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 9435 | 3295 | 323.5 | 200.7 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 9310 | 3270 | 324.0 | 200.6 (AFT) | HVY HOG | DIVE |

COPILOT LATERAL

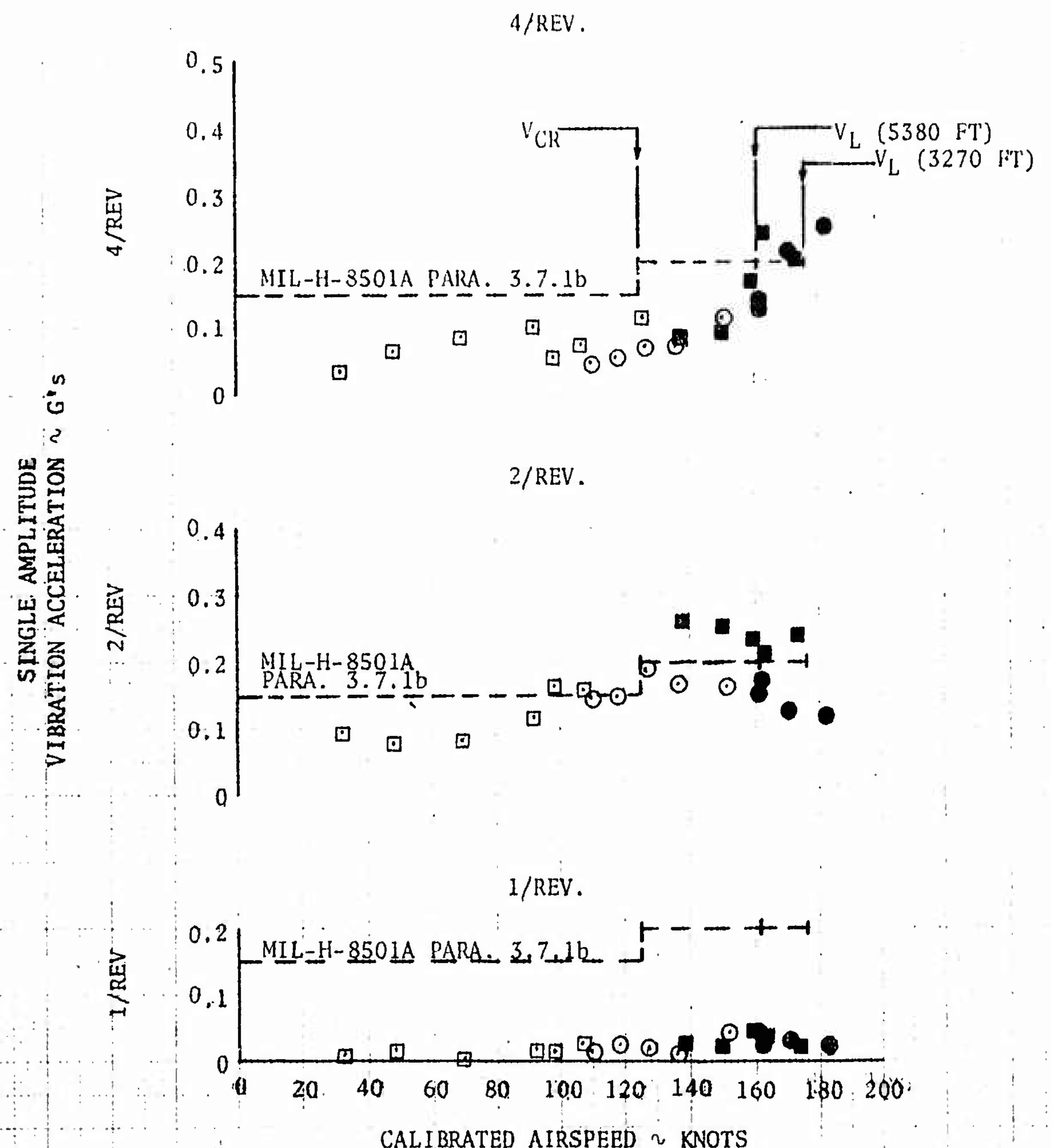


FIGURE NO. 35 CONTINUED

COPILOT LATERAL

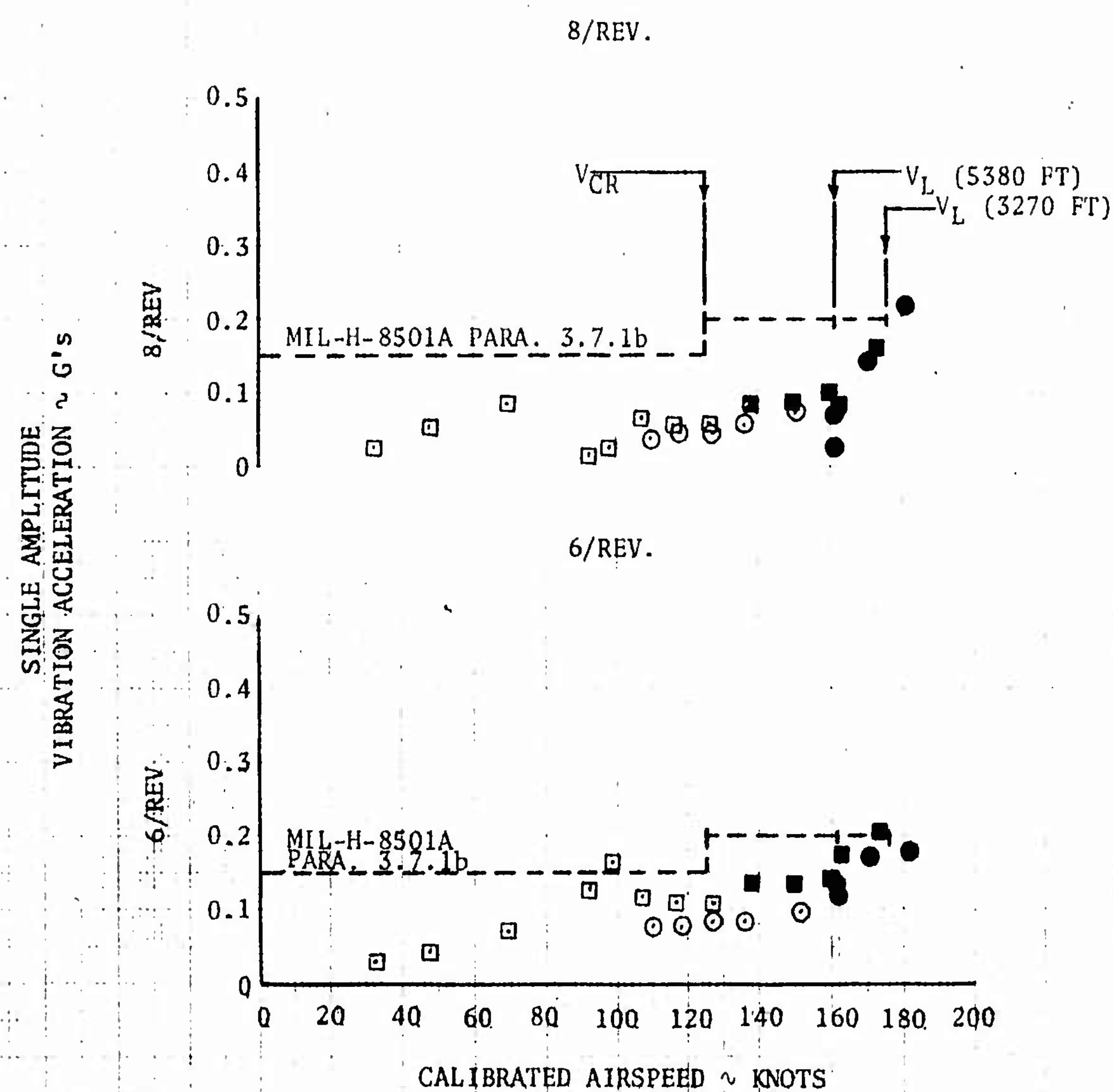


FIGURE NO. 36
VIBRATION CHARACTERISTICS

AH-1G USA S/N 715695

| SYM | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 9435 | 3295 | 323.5 | 200.7 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 9310 | 3270 | 324.0 | 200.6 (AFT) | HVY HOG | DIVE |

SITE MOUNTING LATERAL

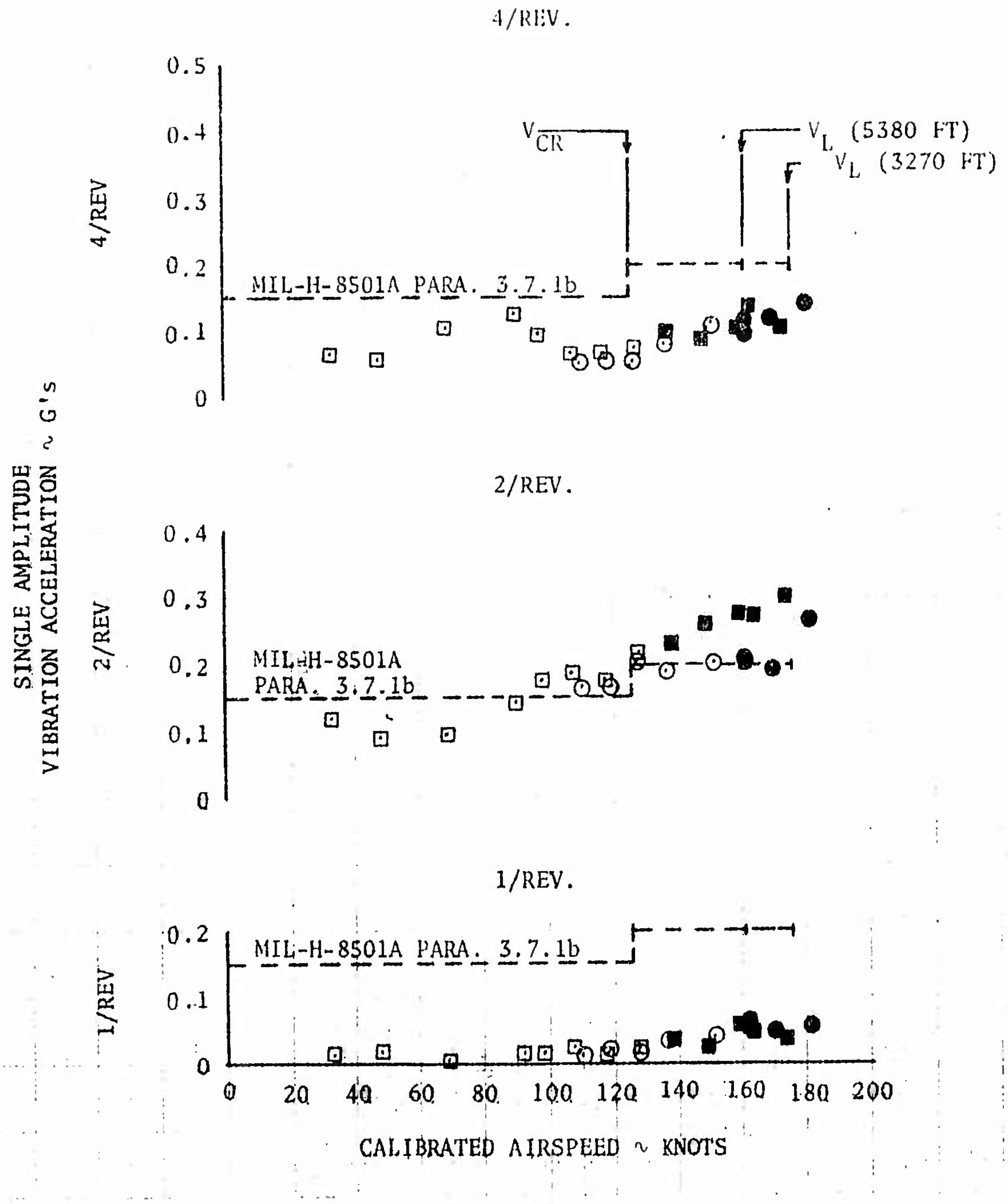


FIGURE NO. 36 CONTINUED

SITE MOUNTING LATERAL

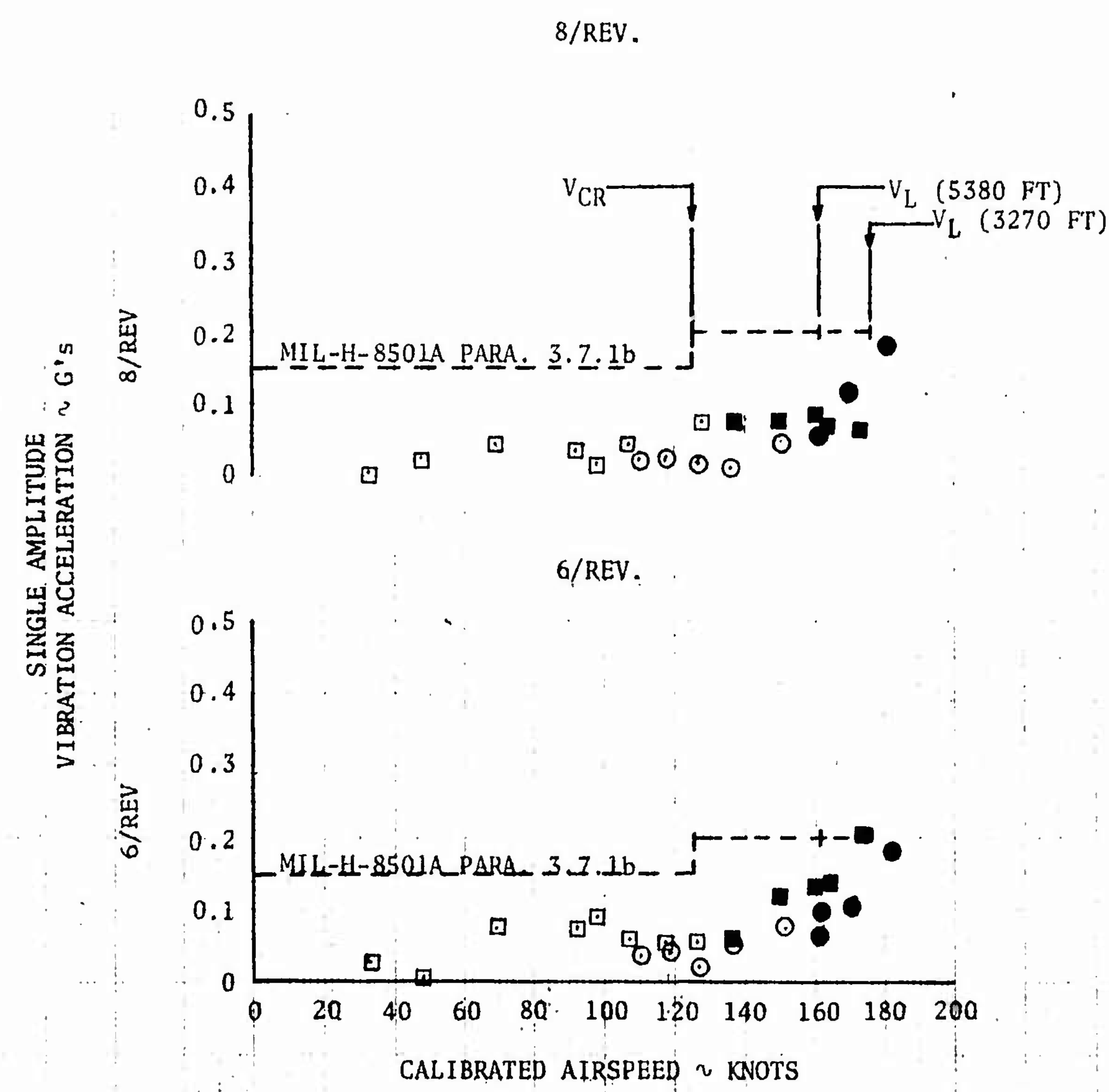


FIGURE NO. 37
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8605 | 14760 | 323.0 | 200.9 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 8540 | 14480 | 322.0 | 200.9 (AFT) | HVY HOG | DIVE |

PILOT VERTICAL

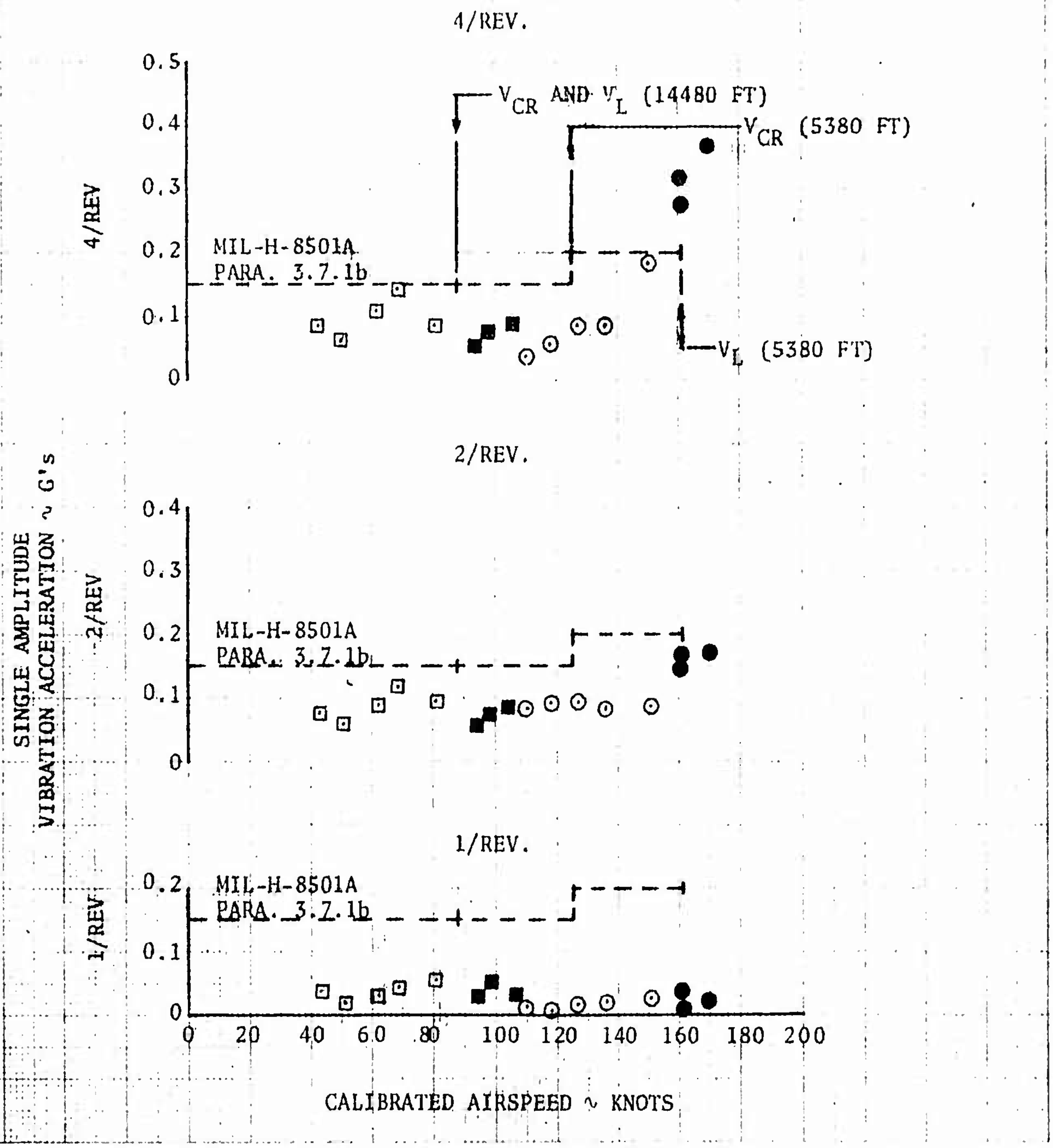


FIGURE NO. 37 CONTINUED

PILOT VERTICAL

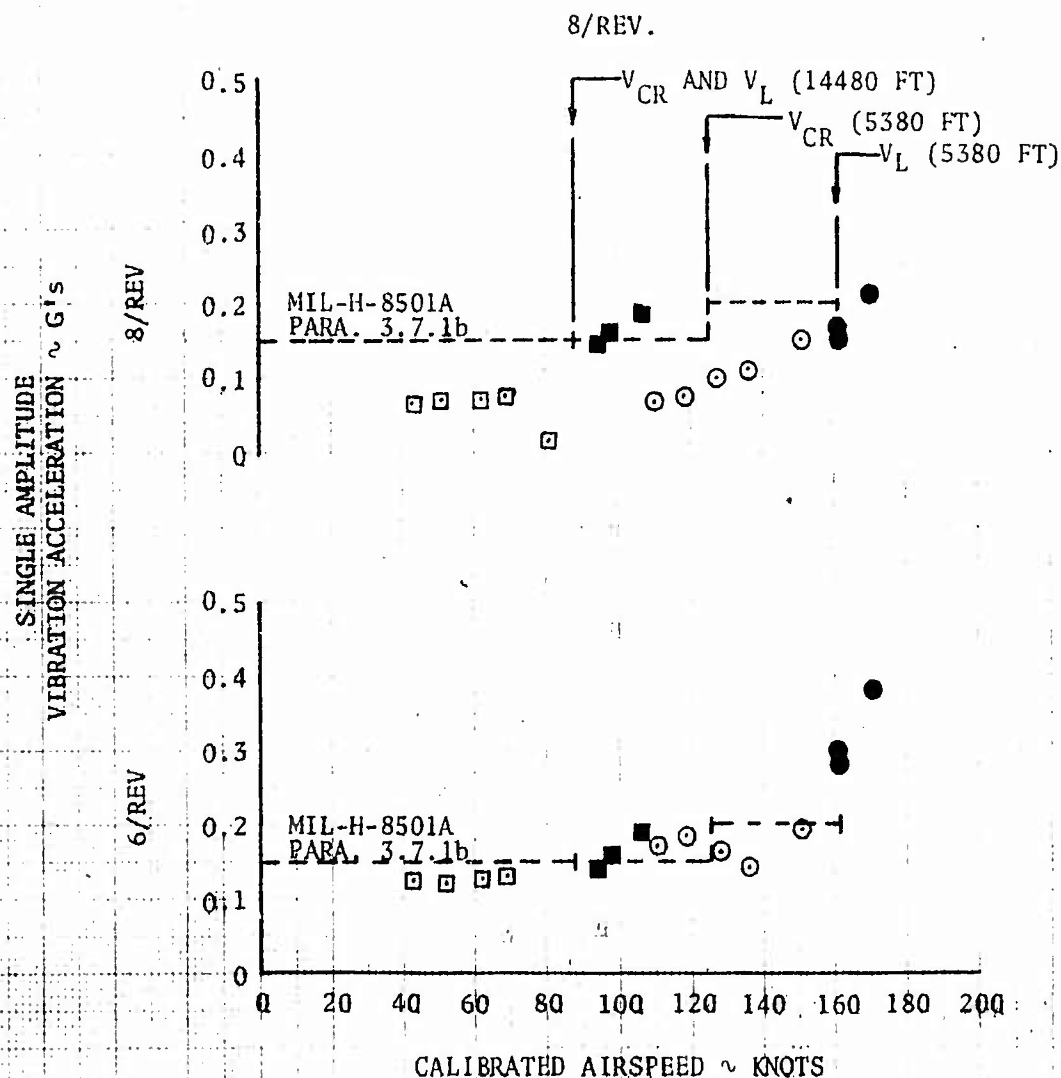


FIGURE NO. 38
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8605 | 14760 | 323.0 | 200.9 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 8540 | 14480 | 322.0 | 200.9 (AFT) | HVY HOG | DIVE |

COPILOT VERTICAL

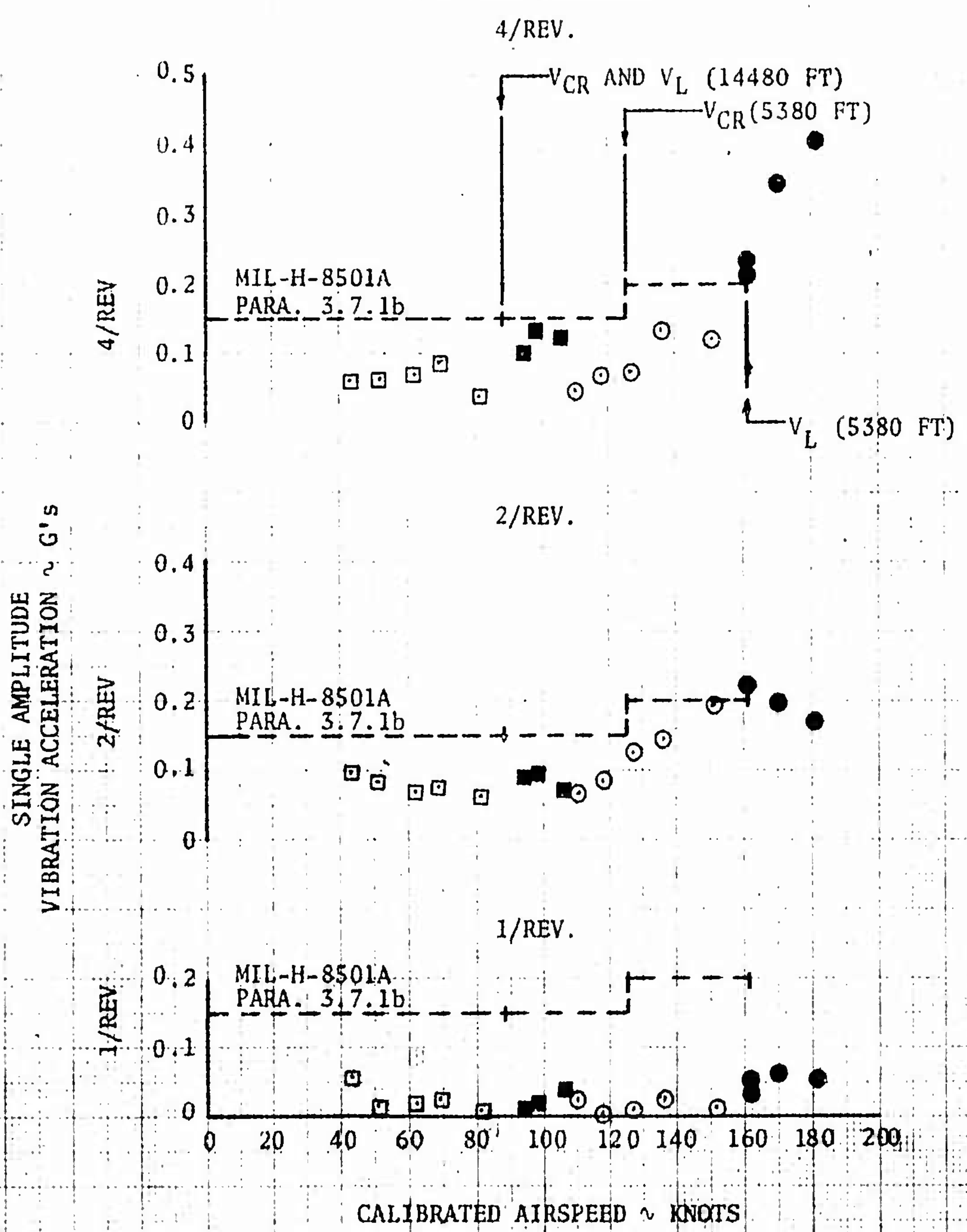


FIGURE NO. 38 CONTINUED

COPILOT VERTICAL

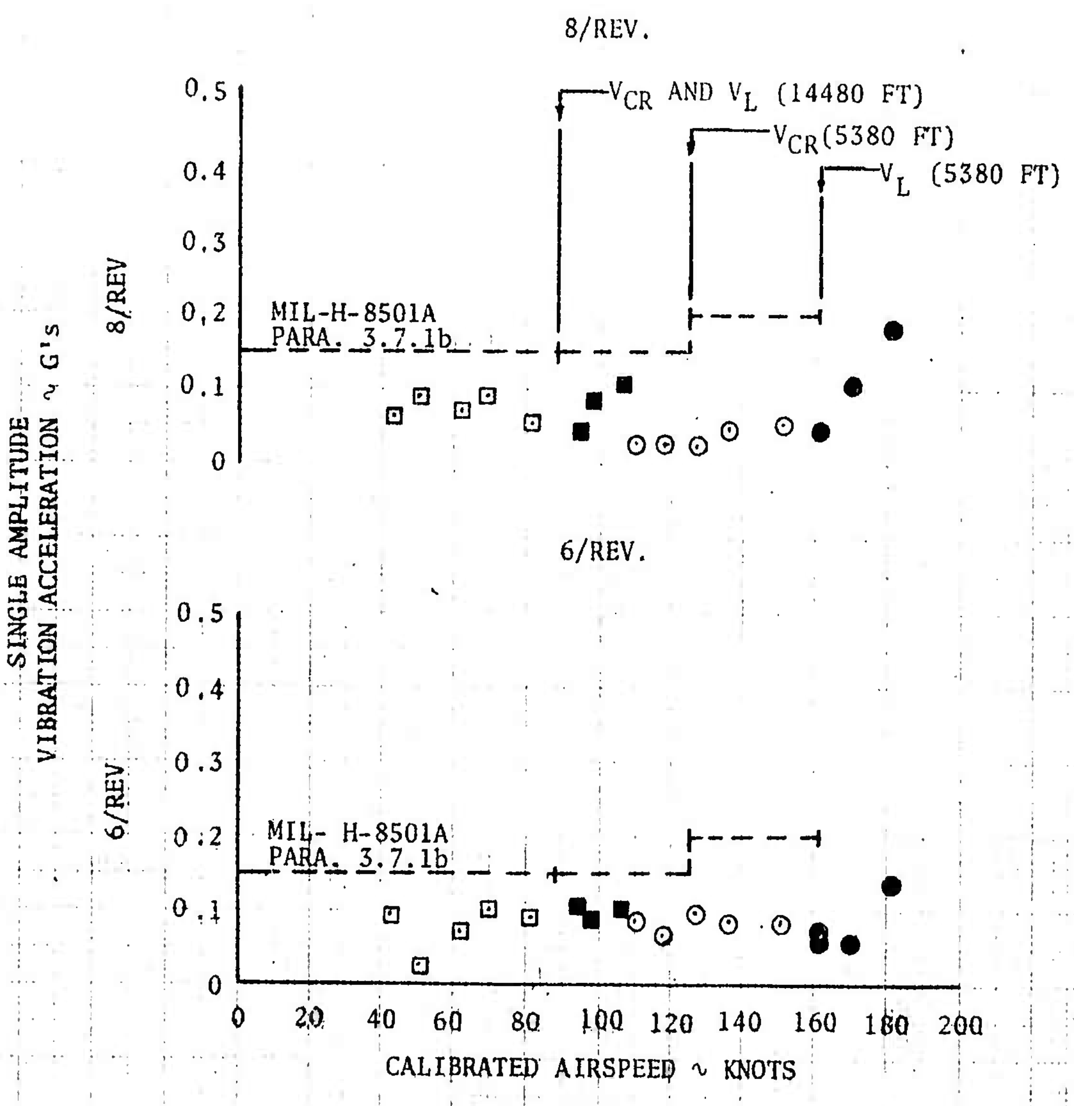


FIGURE NO. 39
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| | 8605 | 14760 | 323.0 | 200.9 (AFT) | HVY HOG | LEVEL FLT. |
| | 8540 | 14480 | 822.0 | 200.9 (AFT) | HVY HOG | DIVE |

SITE MOUNTING VERTICAL

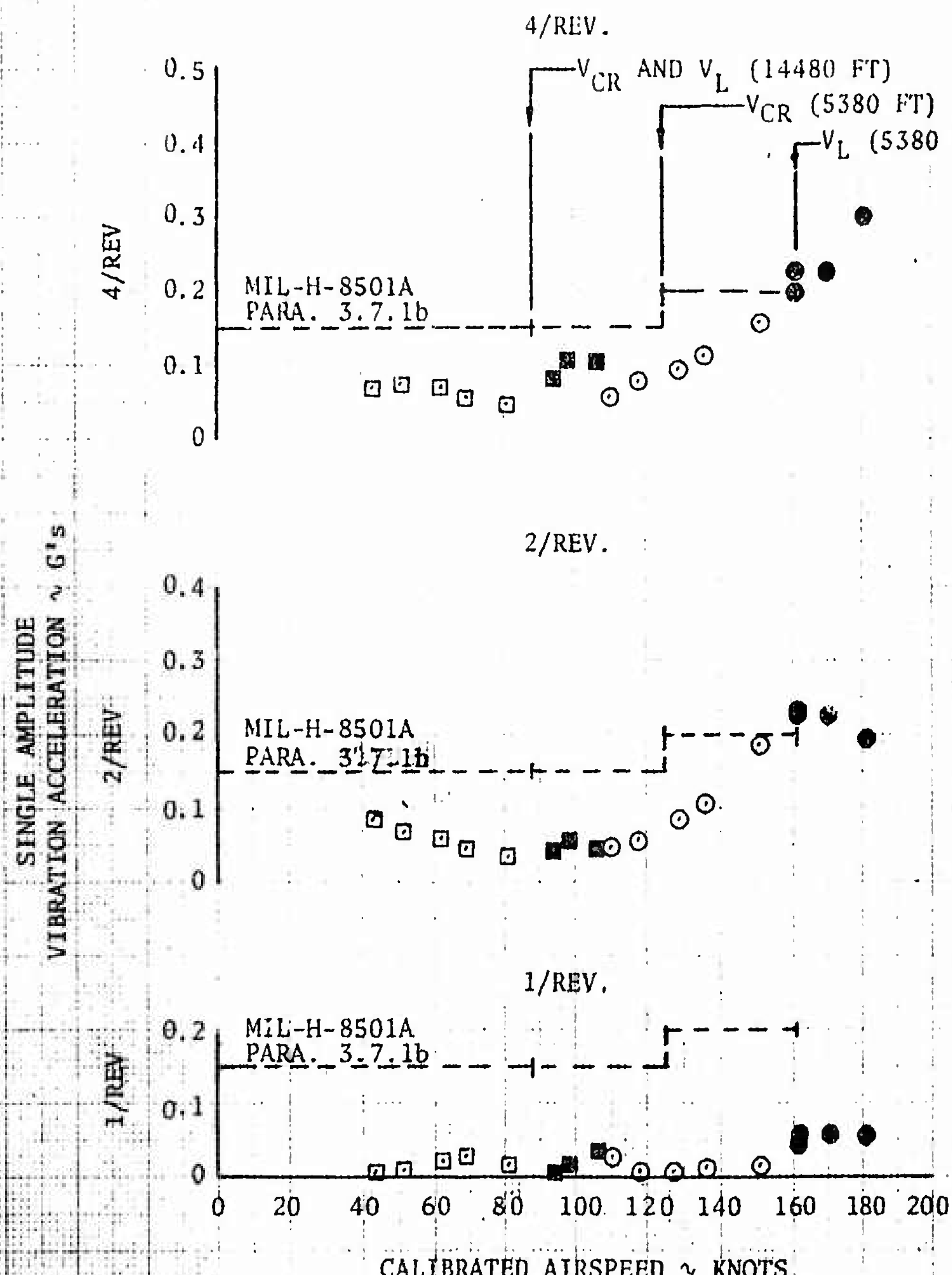


FIGURE NO. 39 CONTINUED

SITE MOUNTING VERTICAL

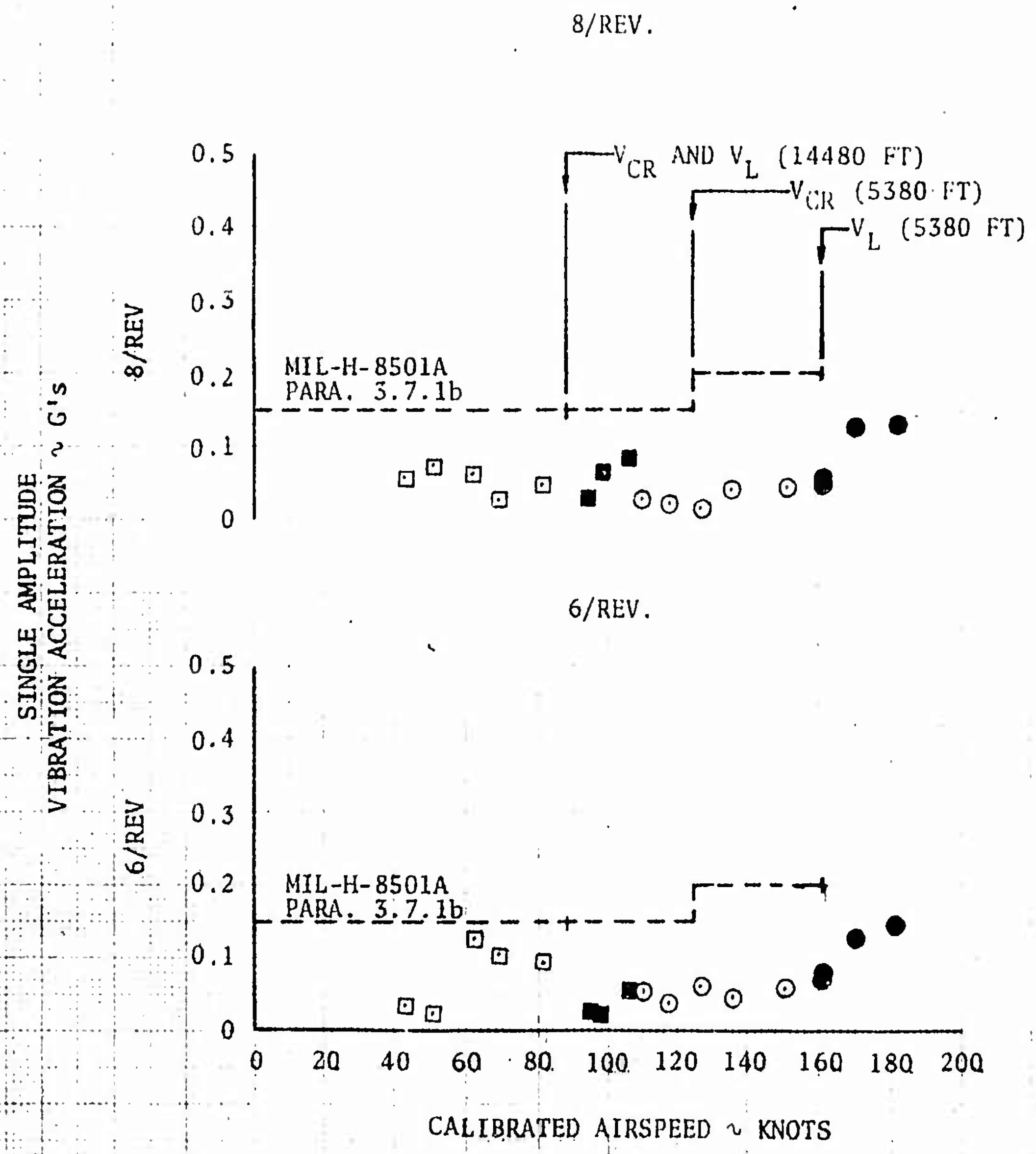


FIGURE NO. 40
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ~ POUNDS | DENSITY ALTITUDE ~ FEET | ROTOR SPEED ~ RPM | C.G. STATION ~ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8605 | 14760 | 323.0 | 200.9 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 8540 | 14480 | 322.0 | 200.9 (AFT) | HVY HOG | DIVE |

PILOT LATERAL

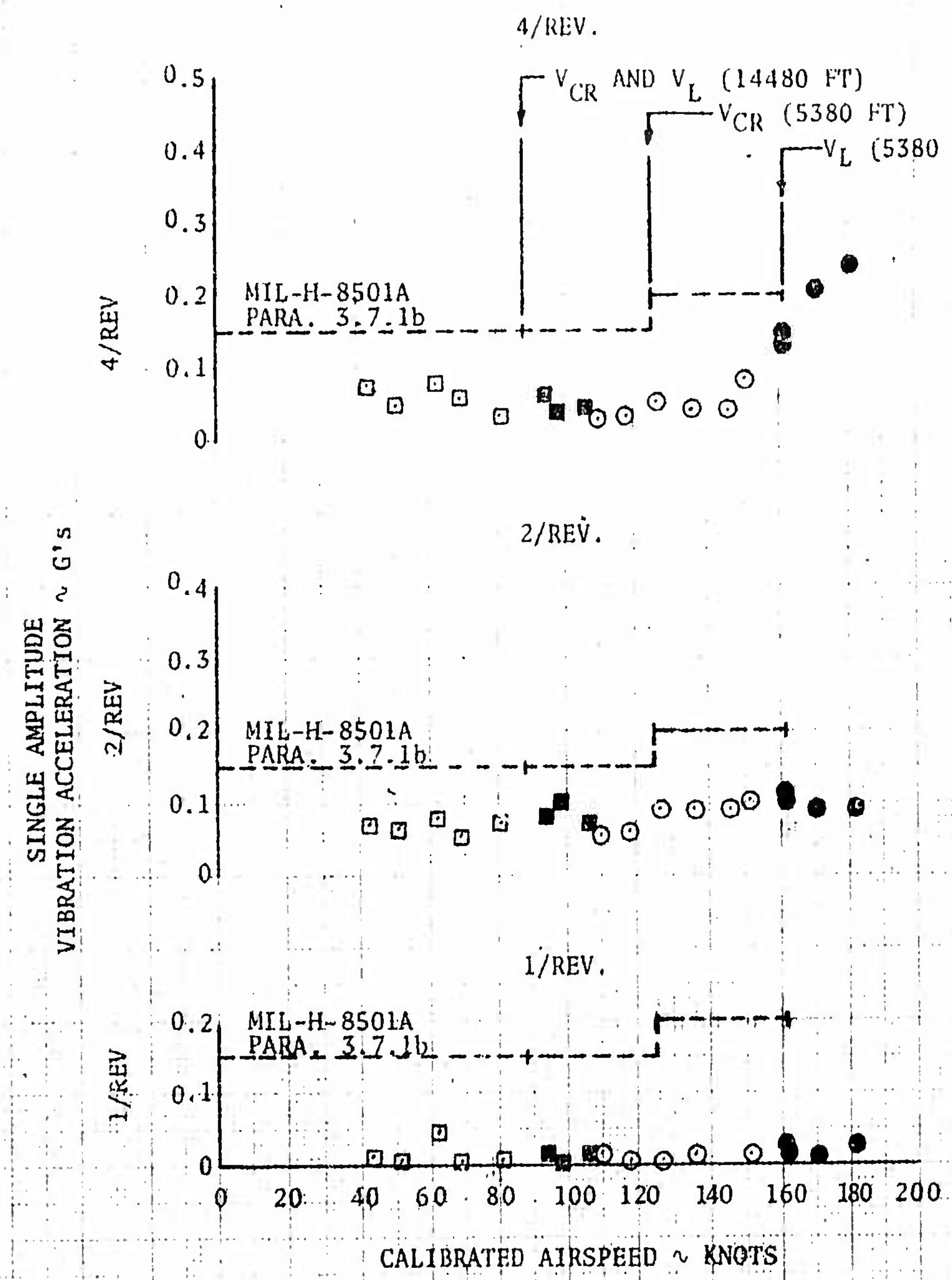


FIGURE NO. 40 CONTINUED

PILOT LATERAL

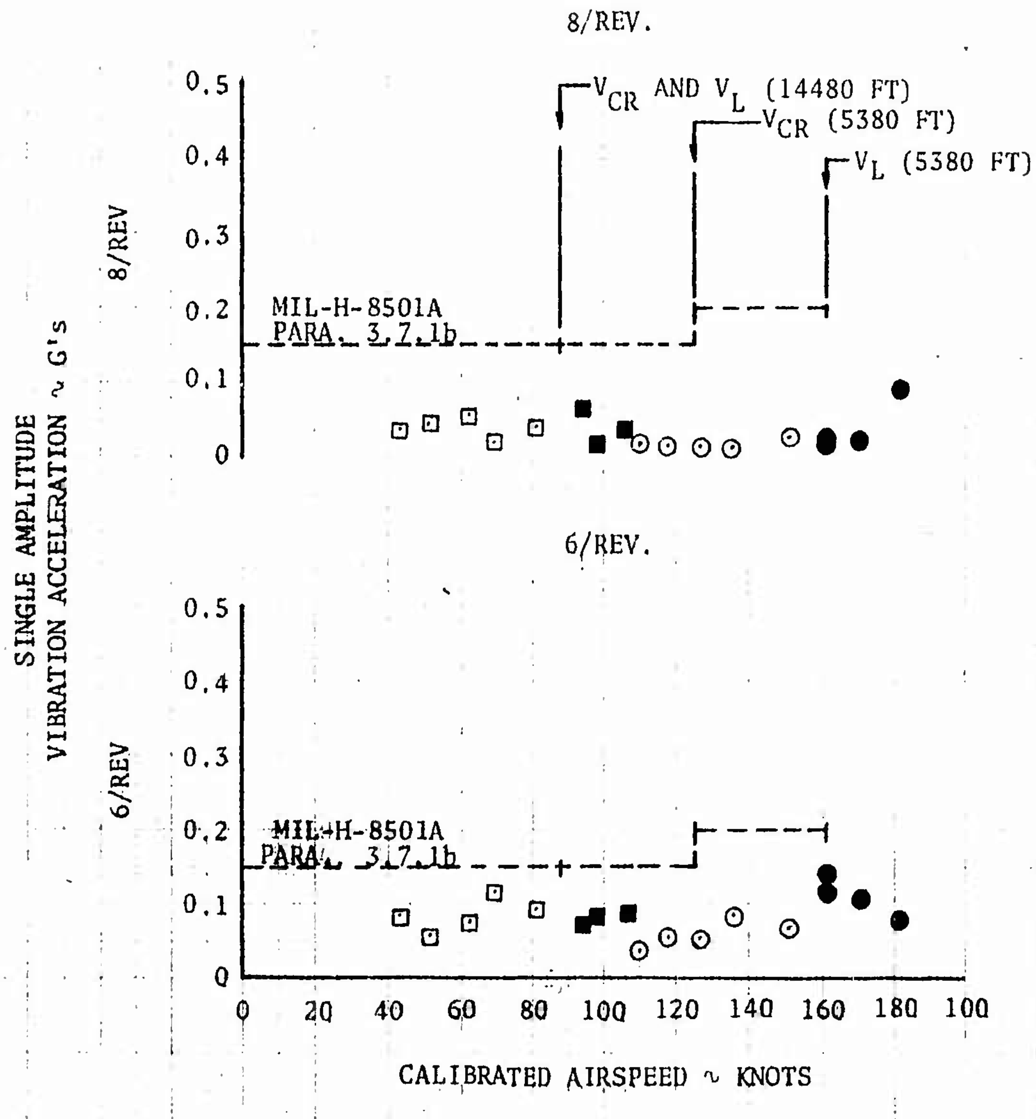


FIGURE NO. 41
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| □ | 8605 | 14760 | 323.0 | 200.9 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 8540 | 14480 | 322.0 | 200.9 (AFT) | HVY HOG | DIVE |

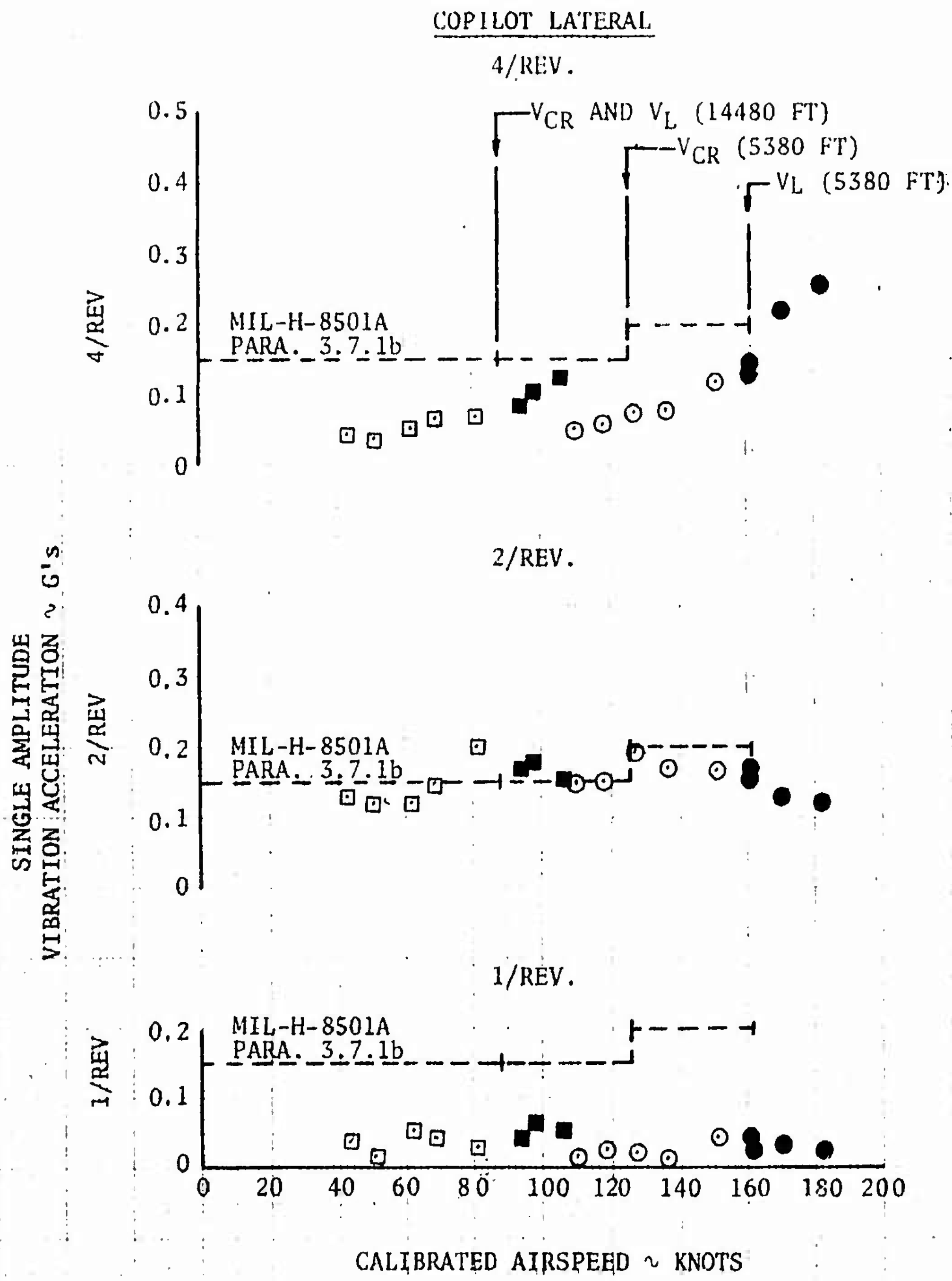


FIGURE NO. 41 CONTINUED

COPILOT LATERAL

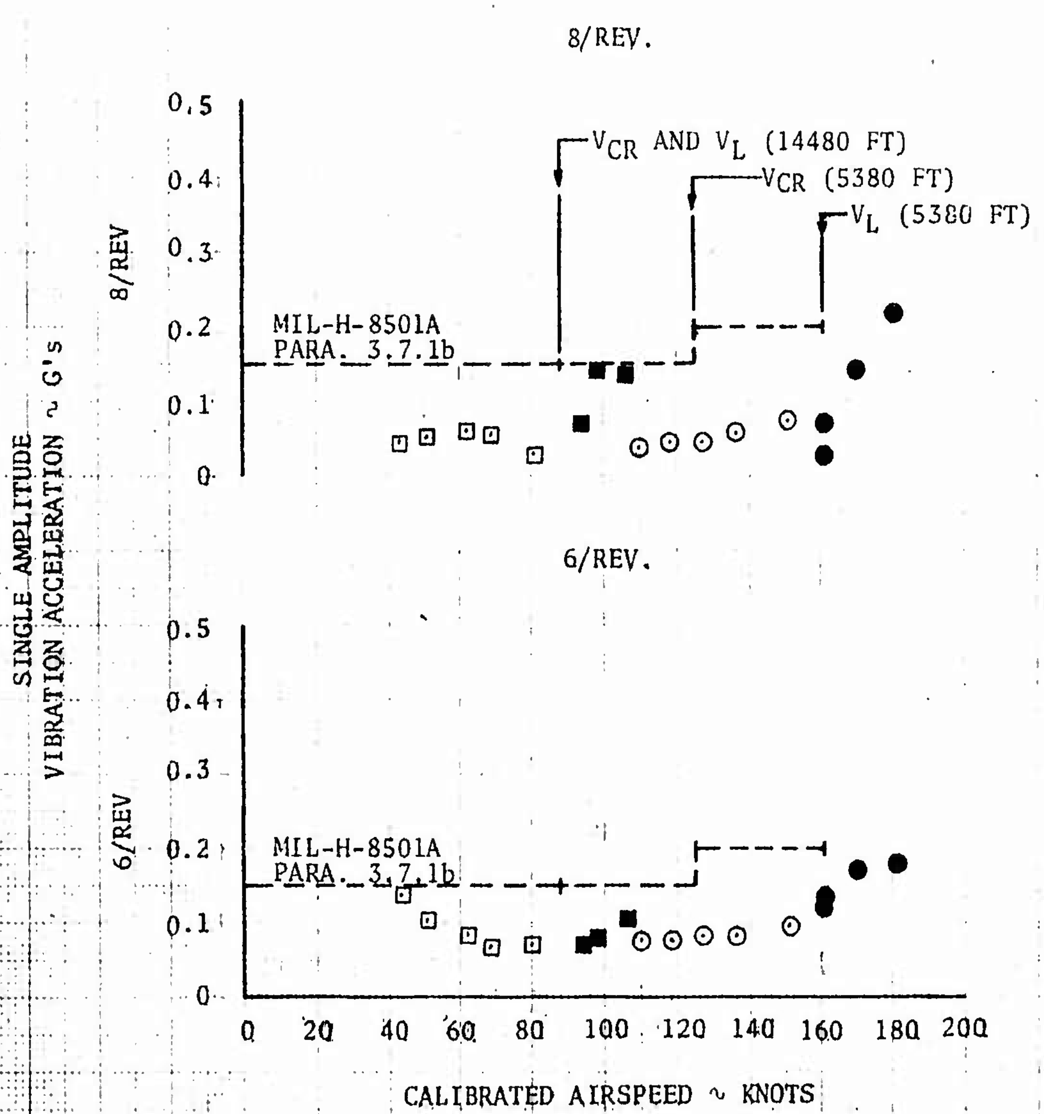


FIGURE NO. 42
VIBRATION CHARACTERISTICS
AH-1G USA S/N 715695

| SYM. | GROSS WEIGHT ∿ POUNDS | DENSITY ALTITUDE ∿ FEET | ROTOR SPEED ∿ RPM | C.G. STATION ∿ INCHES | CONFIG. | FLT. COND. |
|---|---|---|---|---|---|---|
| ○ | 8525 | 5360 | 323.5 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ● | 8640 | 5380 | 324.5 | 201.0 (AFT) | HVY HOG | DIVE |
| ◻ | 8605 | 14760 | 323.0 | 201.0 (AFT) | HVY HOG | LEVEL FLT. |
| ■ | 8540 | 14480 | 322.0 | 201.0 (AFT) | HVY HOG | DIVE |

SITE MOUNTING LATERAL

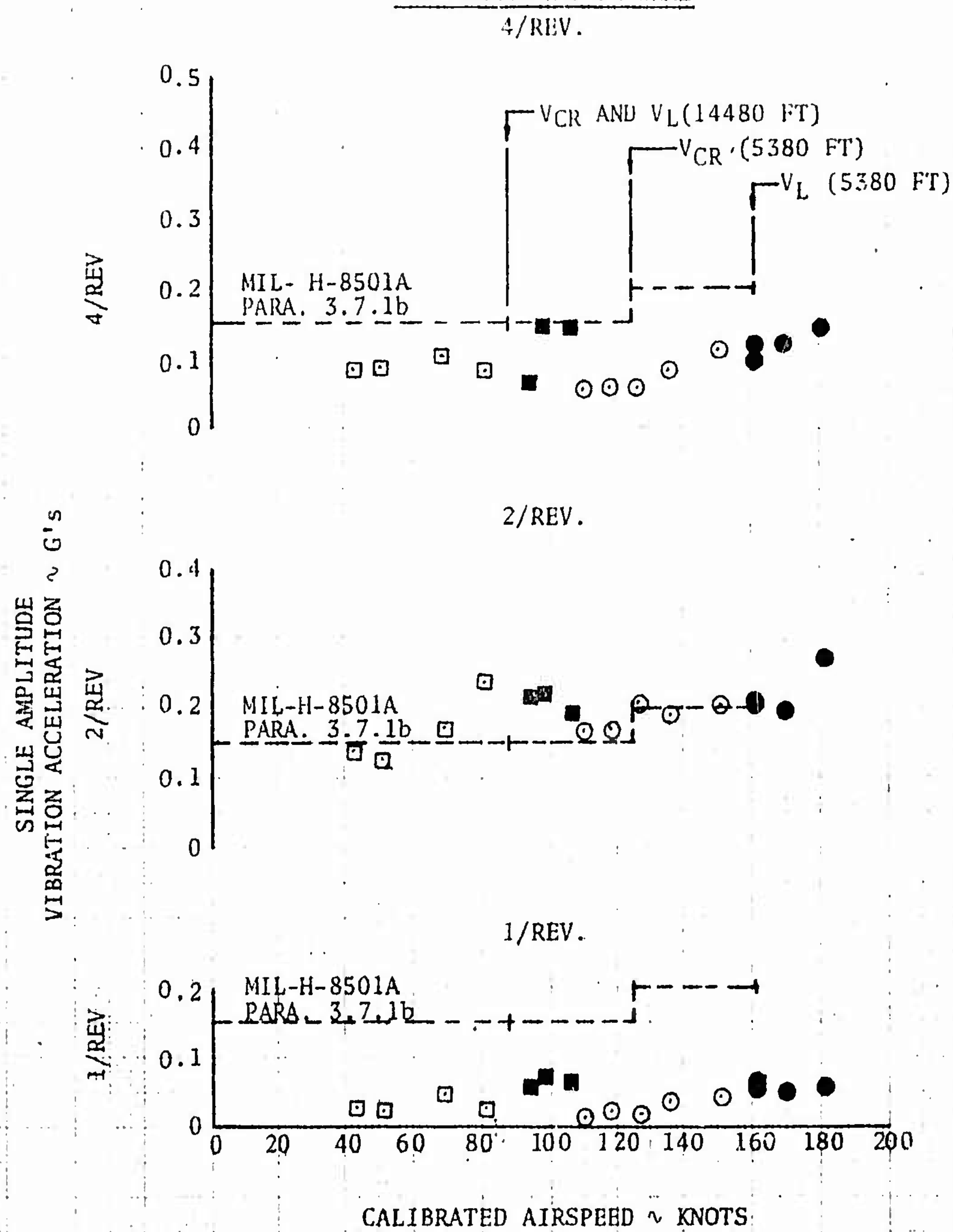
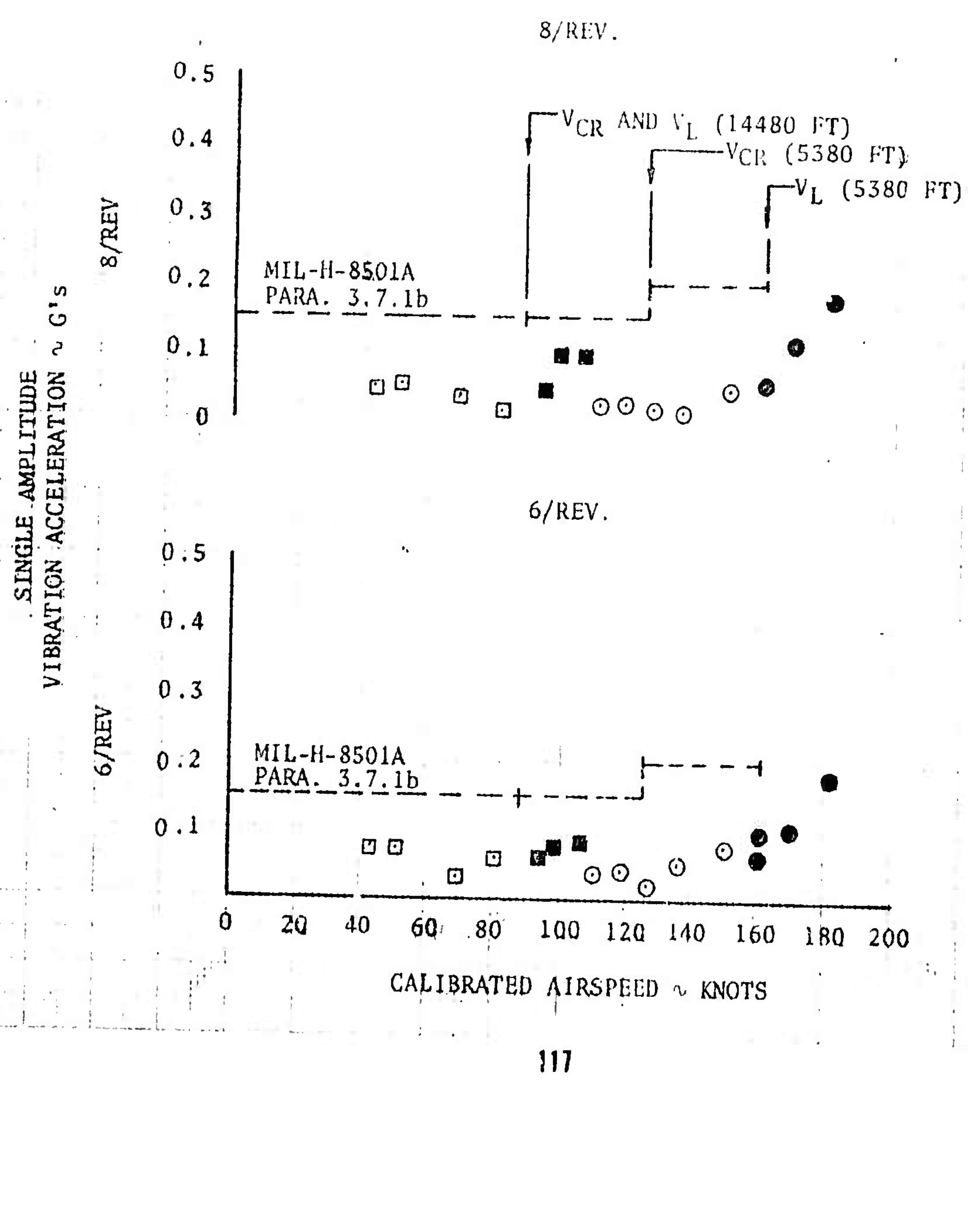


FIGURE NO. 42 CONTINUED

SITE MOUNTING LATERAL



# APPENDIX VII. SYMBOLS AND ABBREVIATIONS

| Abbreviation | Definition | Unit |
|---|---|---|
| ALT | Altitude | foot |
| AVG | Average | -- |
| BL | Buttline | inch |
| COEFF | Coefficient | -- |
| CG, cg | Center of gravity | -- |
| COND | Condition | -- |
| CONF | Configuration | -- |
| CPS, cps | Cycles per second | -- |
| DEG, deg | Degrees | degree |
| DESCRIPT | Description | -- |
| DWN | Down | -- |
| FLT | Flight | -- |
| FT | Feet | foot |
| FS | Fuselage station | inch |
| FWD, fwd | Forward | -- |
| GRWT, grwt | Gross weight | pound |
| in. | Inch, inches | inch |
| KCAS | Knots calibrated airspeed | knot |
| LB, lb | Pound, pounds | pound |
| LAT | Lateral | -- |
| LT | Left | -- |

| Abbreviation | Definition | Unit |
| --- | --- | --- |
| LONG. | Longitudinal | -- |
| MAX, max | Maximum | -- |
| MIN, min | Minimum | -- |
| NO., no. | Number | -- |
| REF, ref | Reference, referred | -- |
| RT | Right | -- |
| SCAS | Stability and control augmentation system | -- |
| SEC, sec | Second | -- |
| SL | Sea level | -- |
| S/N | Serial number | -- |
| STD, std | Standard | -- |
| SYM | Symbol | -- |
| WL | Waterline | inch |

| Symbol | Definition | Unit |
| --- | --- | --- |
| A | Rotor disc area | $ft^2$ |
| $C_T$ | Thrust coefficient | -- |
| $H_D$ | Density altitude | foot |
| $H_P$ | Pressure altitude | foot |
| R | Rotor radius | foot |
| $V_{cal}$ | Calibrated airspeed | knot |

| Symbol | Definition | Unit |
| --- | --- | --- |
| $V_H$ | Maximum airspeed for level flight | knot |
| $V_L$ | Limit airspeed | knot |
| $\rho$ | Air mass density | $slug/ft^3$ |
| $\Omega$ | Rotor rotational frequency | rad/sec |

| Subscript | Definition |
| --- | --- |
| a | Ambient |
| std, s | Standard |
| t | Test |

# APPENDIX VIII. DISTRIBUTION

| Agency | Test Plans | Interim Reports | Final Reports |
|---|---|---|---|
| Commanding General<br>US Army Aviation Systems Command | | | |
| ATTN: AMSAV-R-F | 5 | 5 | 6 |
| AMSAV-C-A | - | - | 2 |
| AMSAV-D-ZDOR | - | - | 2 |
| AMSAV-R-EH | 1 | 1 | 2 |
| AMSAV-C-W | - | - | 2 |
| AMSAV-R-R | - | - | 1 |
| PO Box 209<br>St. Louis, Missouri 63166 | | | |
| Commanding General<br>US Army Materiel Command<br>ATTN: AMCPM-AAWS<br>PO Box 209<br>St. Louis, Missouri 63166 | 5 | 1 | 5 |
| Commanding General<br>US Army Materiel Command | | | |
| ATTN: AMCRD | 2 | 1 | 2 |
| AMCAD-S | - | - | 1 |
| AMCPP | - | - | 1 |
| AMCMR | 2 | - | 2 |
| AMCQA | - | - | 1 |
| Washington, D. C. 20315 | | | |
| Commanding General<br>US Army Combat Developments Command<br>ATTN: USACDC LnO<br>PO Box 209<br>St. Louis, Missouri 63166 | 11 | 11 | 11 |
| Commanding General<br>US Continental Army Command<br>ATTN: DCSIT-SCH-PD<br>Fort Monroe, Virginia 23351 | - | - | 1 |

| Agency | Test Plans | Interim Reports | Final Reports |
|---|---|---|---|
| Commanding General<br>US Army Test and Evaluation Command | | | |
| ATTN: AMSTE-BG | 2 | 2 | 2 |
| USMC LnO | 1 | 1 | 1 |
| Aberdeen Proving Ground, Maryland 21005 | | | |
| Commanding Officer<br>US Army Aviation Materiel Laboratories | | | |
| ATTN: SAVFE-SO, M. Lee | - | - | 1 |
| SAVFE-TD | - | - | 2 |
| SAVFE-AM | - | - | 1 |
| SAVFE-AV | - | - | 1 |
| SAVFE-PP | - | - | 1 |
| Fort Eustis, Virginia 23604 | | | |
| Commanding General<br>US Army Aviation Center<br>Fort Rucker, Alabama 36362 | 1 | 1 | 1 |
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13. ABSTRACT

The Phase D, Part 3 Airworthiness and Qualification Aircraft Vibration Tests of the AH-1G Helicopter were conducted in California at Edwards Air Force Base and auxiliary tests sites during the period 13 June 1968 through 29 July 1969. Six vibration parameters were evaluated to determine model specification compliance and mission suitability information for inclusion in technical manuals and other publications. The vibration levels of the AH-1G met all requirements of the detail model specification; however, a reduction in the vibration levels at airspeeds from maximum level-flight airspeed ($V_H$) to limit airspeed ($V_L$) is desirable for improved mission suitability. The detail model specification did not require any specific vibration levels at airspeeds other than $V_H$. Future detail model specifications should contain vibration limits for all flight conditions and aircraft configurations.

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